1 wenty-Seventh Annual Report

OF THE

NEW JERSEY STATE

griculture Experiment Station

AND THE

Nineteenth Annual Report

OF THE

w Jersey Agricultural College Experiment Station

For the Year ending October 31st

35k5

1906

TRENTON, N. J.:
The John L. Murphy Publishing Co., Printers.
1907.

TABLE OF CONTENTS.

TABLE OF CONTENTS.

	PAGES.
Board of Managers	xv
Organization of the New Jersey Agricultural Experiment Stations	xvii
Report of the Treasurer	xix
Report of the Director	1–14
Report of the Chemists	15–116
Fertilizers	15–36
Inspection of Commercial Fertilizers	17
Summary	17, 18
List of Manufacturers	18–20
Wholesale Cost Per Pound in New York	21
Wholesale Prices of Fertilizer Ingredients for 1905	22
Schedule of Trade Values Adopted by Experiment Stations for 1906	22
Average Analyses of Fertilizing Materials	23–33
The Detection of Peat in Commercial Fertilizers	34–36
Fodders and Feeds	36–70
Inspection of Concentrated Feeds	36
Miscellaneous Fodder Analyses	37
Market Prices of Commercial Feeds	38
The Carbohydrates of Sugar Beet Pulp	39–65
Scheme of Analysis	41
Preliminary Analysis	42
Analysis of the Pulp by Official Methods	43
Effect of Various Solvents	43
Materials Removed by Different Treatments	44
Analysis of the Residues	44–46
Examination of the Extracts	46
Petroleum Ether Extract	46
Sulphuric Ether Extract	47
Absolute Alcohol Extract	47, 48
Eighty Per Cent. Alcohol Extract	48–51
Cold Water Extract	51–54
Warm Water Extract	54, 55
Diastase Extract	55, 56
Sulphuric Acid Extract	57–59
Sodium Hydrate Extract	60
Chlorination	60, 61
Summary of Analyses of Extracts	61–63
Summary	64, 65
Note on the Determination of Crude Fiber	65–67
Buckwheat Products—Proposed Standards of Composition	67–70

V. REPORT OF THE CHEMISTS—*Continued.* P
Inspection of Paris Green—Summary..................
Investigations Relative to the Use of Nitrogenous Materials 7
The Wheat Crop of 1906.........................
Composition of the Manures Used...............
The Experiment Plant.........................
Diagram of Experiment.........................
Application of Manures and Fertilizers............
Amounts Applied...............................
The Crop Grown..............................
The Results of the Wheat Experiment, 1906........ 8
Average Amount of Dry Matter in Crop in 1906 and in 1901.. 8
Average Per Cent. of Nitrogen in the Dry Matter in 1906 and in 1901........................... 8
Average Amount of Nitrogen in Crop in 1906 and 1901 9
Average Increase Over the Check Plot, and the Average Per Cent. of Nitrogen Recovered in 1906 and in 1901.. 96
The Availability of the Different Nitrogenous Materials When That of the Nitrate is Taken as 100..
Plant Nutrition Studies............................ 101
Pot Experiments.............................. 101
Lines of Study................................ 101
Plan of Experiment............................ 101
Number of Pots and Treatment................102, 105
Increase Over Nothing Series.....................
Field Experiments at Hammonton.................... 108
The Soiling and Forage Crops Experiment.......... 108
The Soil Improvement Experiment................. 112
Field Experiments With Fertilizers Upon Asparagus..... 113
VI. REPORT OF THE SOIL CHEMIST AND BACTERIOLOGIST.......... 117
Chemical and Bacteriological Factors in the Ammonification of Soil Nitrogen............................... 119
Differentiation of the Chemical and Bacteriological Factors ....
Ammonification Caused by Different Infusions.......
Ammonification by Soils of the Same Origin, but Changed by Fertilizer Treatment................
The Ammonifying Power of Seven Soils of Different Origin ....
Ammonification as Affected by the Chemical Composition of the Soil..............................
Ammonification by Pure Cultures of B. Mycoides....
Ammonification in Gelatin Solutions...............
The Ammonification Coefficients of New and Old Asparagus Soils.................................
Ammonification as Affected by Lime Treatment.....
Ammonification in Gelatin and Peptone Solutions....
Ammonification of Egg-Albumin...................
Ammonification of Cottonseed Meal................

REPORT OF THE SOIL CHEMIST AND BACTERIOLOGIST—*Continued.* PAGES.
Losses of Nitrogen from Peptone Solutions.......... 172
Bacteriological Indications of the Mineral Requirements of Soils............................... 177
Mineral Food Supplied to Azotobacter by Different Soils 178
REPORT OF THE HORTICULTURIST 189–266
Plant-Food Removed by a Peach Tree in Ten Years' Growth 192–203
Composition of Leaves and Total Plant-Food Removed by Them 193
Composition of Prunings and Total Plant-Food Removed by Them 194
Composition of Fruit and Total Plant-Food Removed by it 195
Composition of Tree and Roots and Plant-Food in Them at Time of Removal 196
Summary—Ten Years' Growth 196
Computed Total Amounts of Plant-Food Removed and Equivalent Per Acre in Pounds................. 197
Total Weights 197
Amount of Plant-Food Removed Each Year......... 197
Amounts of Plant-Food Used by the Young and by the Mature Tree 198
Relative Proportions of Plant-Food Used by the Young and by the Mature Tree 198
Relative Amounts of Plant-Food Used 199
Proportions of Plant-Food Used by Different Parts of the Tree 199
Relation of the Size of the Crop to Composition of Leaves 199
Composition of Leaves 200
Stored Food in Twigs 200
Composition of Dry Matter in Old and New Wood... 201
Proportion of Potash and Phosphoric Acid.......... 201
High Amount of Plant-Food Used................. 201
Results at Other Stations 201–203
Composition of Leaves and Prunings of Various Fruit Trees 203
Average Composition of Leaves of Fruit Trees for Ten Years 204
Average Composition of Prunings from Fruit Trees for Ten Years 204
Plant-Food Used by Asparagus in Eight Years' Growth... 205–213
Weight and Composition of Asparagus Tops and Plant-Food Removed by Them 206, 207
Composition of Edible Portion of Asparagus in 1901.. 208
Plant-Food Removed by the Edible Portion of Asparagus Based on the Analyses of 1901............. 209
Amount of Plant-Food Removed Per Acre........... 209
Plant-Food Removed Per Acre by the Four Plots of Palmetto 210

VII. REPORT OF THE HORTICULTURIST—*Continued.* PAGES
Relation of Plant-Food Removed to Fertilizer Applied, 210, 21
Effect of Fertilizers on Composition 21
Composition of the Different Varieties 21
Effect of Rainfall on Composition 212, 21
Asparagus Breeding 213, 21
Fertilizer Trials on Small Fruits and Asparagus......... 214–21
Yields of Asparagus and Blackberries with Different Fertilizers 215, 21
Raspberries 21
Yields of Currants and Gooseberries with Different Fertilizers 217, 21
Irrigation of Small Fruits and Asparagus 218–22
Effect of Irrigation on the Yields of Asparagus and Small Fruits Planted in 1896 .... 219, 22
Varieties of Small Fruits and Asparagus 220–22
Time of Year that Fruit Trees Make Their Growth...... 22
Two Serious Diseases in 1906......................... 224, 22
Blight 22
"Cloudiness" of Pears 224, 22
Spraying 225–23
San José Scale 22
Brown Rot and Curculio on Plums 22
Apples and Pears 22
Eggplants 22
Tomatoes 227, 22
Cantaloupes 22
Spraying Tomatoes and Strawberries in Bloom.......... 229–23
Methods of Making Bordeaux Mixture 231–23
Stock Solutions of Copper Sulphate 234, 23
Expansion of Water when Copper Sulphate Dissolves, 23
Amount of Copper Sulphate in a Saturated Solution.. 235, 23
The Forcing of Tomatoes 237–24
Varieties of Tomatoes for Forcing 23
General Methods of Culture Used 23
Average Yields of Tomatoes, Ten Plants of Each Variety 238, 23
Hand-Pollination Compared with Self-Pollination.... 23
Method of Marketing 239, 24
Best Size of Tomatoes 240, 24
Prices at Different Times of Year 24
Total Income 241, 24
Fumigation for the White Fly (Aleyrodes).............. 24
Appearance of Injured Plants 24
Details of Fumigation Experiment 24
How Dangerous is the Gas 243, 24
Effect on Other Kinds of Plants 244, 24
Results of Experiments 24
How to Fumigate 245, 24
Fumigation Trials 24
Fumigation of Regular Tomato-House 24
Bean Variety Test for Forcing 24
Yields of Beans.................................. 24

	PAGES.
11. REPORT OF THE HORTICULTURIST—*Continued.*	
Varieties of Radishes for Forcing	249
The Use of Ether in Forcing Asparagus, Rhubarb and Strawberries	249–252
Etherizing Chamber	249
Asparagus	249–251
Rhubarb	251, 252
Strawberries	252
Preservation of Greenhouse Benches	252, 253
The Yields in the Orchards	254–263
Fertilizer—Amounts and Time of Application for the Various Fruit Trees	254
Plums	255
Cherries	256
Apples	257, 258
Standard Pears	259, 260
Dwarf Pears	261–263
Precipitation Records	264, 265
II. REPORT OF THE DAIRY HUSBANDMAN	267–310
Feeding Experiments	269, 270
Home-Grown Protein *v.* Purchased Protein	269
Gluten Feed *v.* Dried Corn Distillers' Grains	269
Corn Silage *v.* Soiling Crops for Summer Feeding	270
Forage Crop Experiments	270–281
Soiling Crops, 1906	270–275
Acreage, Date of Planting and Cutting, and Yield of Soiling Crops	273, 274
Cost and Total Nutrients in Fodders	275
Field Notes	275–279
Rye and Wheat	275, 276
Alfalfa	276
Barnyard Millet	276
Thoroughbred White Flint Corn	277
Kaffir Corn and Cow Peas	278
Cow Peas	278, 279
Experiments with Growing Different Varieties of Cow Peas, Millet, Sorghum, Sorghum Combinations, Milo Maize, Kaffir Corn, etc.	279
Field Crops	279–281
Alfalfa	279, 280
Top-Dressing Alfalfa With Lime	280, 281
Experiment With Alfalfa Seed from Washington	281–286
Hay Caps for Curing Alfalfa Hay	286
Crimson Clover	286, 287
Oats and Peas	287, 288
Millet	288
New Seeded Grass	289
Fertilizer Experiment With Corn	289–291
Amount of Phosphoric Acid Supplied to Each Acre	290
Analysis of Fertilizers—Pounds in One Hundred	291
Cost of Silage	292
Experiments With Vetches and Lupines	293, 294
Experiment With Seeds from Denmark	294, 295

VIII. REPORT OF THE DAIRY HUSBANDMAN—*Continued.* PAGES.
Records of Yield, Cost of Production and Net Income from Seventy-six Acres 295–297
Cost of Producing Milk 298–302
Cost of Feeds and Amount Consumed—Two Years .. 298, 299
Proportion of Feed to Roughage 299
Production of Milk, Fat and Butter 300
Cost of Milk, Fat and Butter 300, 301
Average Value of Product and Profit from Herd 301, 302
Manurial Value of Purchased Feeds 303, 304
Treatment of Milk Fever Case 304
Record of the Dairy Herd 305–310
Individual Record of Dairy Herd for Two Years 306
Profit from Milk 307
Profit from Butter 308, 309
IX. REPORT OF THE BIOLOGIST 311–367
I. Experimental Studies in Oyster Propagation 313–354
Introduction 313
The Barnegat Laboratory 314
The Mullica Station 315
Causes of Slow Progress 315
Need of Larger Appropriation 316
Lines of Investigation 317
Summary of Results 317
Our Oyster Resources 320
Journal of Operations 321–351
Operations at Barnegat ....
321, 322, 325, 331, 334, 338, 343, 347, 348
Operations at Tuckerton and the Mullica ....
321, 324, 330, 332, 337, 339, 345, 347, 349
Explanation of the Plates 351–354
Plates I. to XIV 354
II. Egg Production of Virgin Fowls (concluded) 355–358
III. Application of Von Behring's Method of Immunizing Cattle Against Tuberculosis 359–367
X. REPORT OF THE BOTANIST 369–514
Summary 371–374
The Experiment Area, or Garden 374, 375
Experiments with Sweet Corn 376–392
"Malakhov-Premo"-"Malamo" 376–378
Reports from Testers of the "Malamo" 378, 379
"Malakhov-Crosby"-"Malakosby" 379, 380
Reports from Testers of the "Malakosby" 380, 381
The "Adams-Crosby" Cross 381, 382
The "Mexican-Gentleman" Crosses 382, 383
"Mexican-Gentleman" (Solid Black Grains) 383
"Mexican-Gentleman" (White Zigzag Grains) 383, 384
"Mexican-Gentleman" (White Straight-Rowed Grains), 384, 385
Other "Black Mexican" Crosses upon Home Grounds, 385–388
"Golden Bantam" Crosses of Sweet Corn 388–392
Experiments with Various Flint Corns 393–396
A Primary Breeding Plot of Sweet Corn 396–401
The Four Breeders 401

[.] REPORT OF THE BOTANIST—*Continued.* PAGES.
"Black Mexican" and Other Crosses—Co-operative Tests, 401–406
Cross of "Eight-Rowed" and "Black Pop" 406
"Voorhees Red" Sweet Corn 407, 408
General Notes upon Corn 408–410
Experiments with Tomatoes 410–431
Old Varieties Grown the Present Season 410, 411
Novelties or Varieties Not Before Grown in the Gardens 411, 412
Notes upon Some of the Leading Crosses 412, 413
Reports from Testers of "Magnerosa" Tomato 413–415
The "Marvelosa"-("Marvel-Ponderosa") 415–417
Reports from Testers of "Marvelosa" Tomato 417
"Arcadia-Earliana" Tomato 418
"Arcadia-Cumberland" Tomato 418
"Magnus-Crimson Cushion" Tomato 419
"Crimson Cushion-Marvel" Tomato 419, 420
"Earliana-South Jersey" Tomato 420
"Bright and Early-Nolt's Earliest" Tomato 420
"Fortune-Earliana" Tomato 421
"Giant-Ponderosa" Tomato 421
"Honor Bright-Fortune" Tomato 421, 422
"Magnerosa" 422
"Magnerosa" upon "Aristocrat-Extra Early Tree" 422
"Ponderosa-Duke of York" 422
"Stone-Best of All" 422
"Aristocrat-Lemon Blush" 423
"Dwarf Stone-Enormous" 423
"Globe-Duke of York" 423, 424
"Station Yellow-Dwarf Stone" 424
Some of the "Globe" Crosses 424, 425
"Red Currant-Dwarf Champion" 425, 426
Narrow-Leaved Tomato Plants 426
Tomato Plants from Cuttings 426–428
General Remarks upon Tomato Experiments 428–431
Experiments with Eggplants 431–445
Reports upon the "Jersey Belle" Eggplant 431–433
"Black Snake" upon "Dwarf Purple" 433
"Black Snake" upon "Early Dwarf Oval" 433
"Black Snake" upon "New York Improved" 433
"Black Pekin" upon "Black Snake" 434
"Dwarf Purple" upon "Black Beauty" 434
"Dwarf Purple" upon "New York Improved" 434
"Jersey Belle" upon "Black Snake" 434
"Jersey Belle" upon "Excelsior Tree" 435
"Long White" upon "Black Snake" 435
"Long White" upon "Black Beauty" 435
"Pride of Sunnyside" upon "Black Beauty" 435
"Long White" upon "New York Improved" 436
Hybrid Eggplants 436–439
A Derivative "American-Chinese" Eggplant Hybrid 439–441
"Pride of Sunnyside" upon "Scarlet Chinese" 441, 442
Reciprocal Hybrids of American and Chinese Eggplants 442, 443

X. Report of the Botanist—*Continued.* PAGE
General Notes upon Eggplants 444, 4
Experiments with Lima Beans 446–4
Reports upon "Station" Bush Lima 447, 4
Selection Experiment with the "Jackson Wonder" Lima 448, 4
Crosses of the "Jackson Wonder" Lima 449–4
Further Notes upon the Above Crosses 452, 4
Notes upon Pole Lima Beans 453, 4
Experiments with Bush Beans 454–4
Some Promising Crosses of Bush Beans 454–4
Further Notes upon Seeds of the Above-Named Bean Crosses 457–4
Less Desirable Crosses of Bush Beans 460–4
Rejected Crosses of Bush Beans 463–4
Novelties in Bush Beans 466–4
Notes, with Engravings, of "Crystal Wax" Crosses ... 4
Spraying Experiments with Bush Beans 471, 4
"Natural Suspect" Beans 472, 4
Mature and Immature Beans for Seeds 4
Scarlet Runner Hybrids 473–4
General Notes upon Beans 476, 4
Experiments with Squashes 478–4
The "Jug" Type of Squash 4
Growers' Notes upon Station Summer Squash No. 1, 4
Experiments with Winter Squashes 483–4
Growers' Notes upon Station Winter Squash No. 1.. 4
Notes upon Squash Seeds 489–4
Experiments with Peas 491–4
Experiments with Salsify 495–4
Salsify in the Old Plot 497, 4
Notes upon Udo 498, 4
Chinese Vegetables 499, 5
Experiments with Okra ("Gumbo") 501, 5
Experiments with Onions 5
Experiments with Ornamental Plants 503–5
Test of Rust-Resisting Cantaloupes 506–5
Rainfall of the Growing Season for Past Seventeen Years, 5
Temperature of the Growing Season for Past Seventeen Years 5
Sunshine of the Growing Season for Past Seventeen Years, 5
Weather Notes of the Growing Season 5
XI. Report of the Entomologist 515–6
General Review 517–5
Scale Insects 517–5
San José Scale 5
Oyster-shell Bark-louse 5
Scurfy Scale 5
Rose Scale 5
Cottony Maple Scale 5
Maple Pseudococcus 5
Tulip Soft Scale 5
Peach Soft Scale 5

REPORT OF THE ENTOMOLOGIST—*Continued.* PAGES.

Orchard Insects 520-523
Plum Curculio 520
Apple Curculio 520
Pear Blister Mite 520
Leaf Mites 521
Pear Psylla 521
Insects on Field Crops 523-525
Army Worm 523
Corn-stalk Borer 523
Cabbage Worms 523
Grasshoppers 523
Asparagus Beetles 524
Root Maggots 524
Flea Beetles 524
Wire Worms 524
White Grubs 525
Cut Worms 525
Shade Tree Insects 525-527
Catalpa Hawk Moth 525
Yellow-necked Caterpillars 527
Grape Galls 528
Rose Chafer 528
Plant Lice 529
Beneficial Insects 529, 530
Chilocorus similis 529
Pentilia misella 529
Chinese Mantis 530
Miscellaneous 530
Record of the Experiment Orchard 532-538
Entomology in the Crop Bulletin 539, 540
The Army Worm 540-545
The Gypsy Moth 546-548
Root Maggots 548-558
Materials to be Tested 551
Riverton Experiments 553
Husted Experiments 555
Matawan Experiments 556
Other Experiments 558
The Periodical Cicada 559-561
Shade-tree Insects 561-569
Newark 561
The Elm-leaf Beetle 564
East Orange 565
Montclair 567
Hoboken 567
Rahway 568
Other Towns 569
The Signate Lady-bird Beetle 570
San José Scale 573-579
Insecticides 580-606
Arsenate of Lead 580
Paris Green 583

XI. Report of the Entomologist—*Continued.*
Antidin
Killarvae
Miscellaneous
Lime and Sulphur Washes
Scalecide
Target Brand
Kill-O-Scale
Scale-Skidoo
The Camden Mixture
Mechanical Emulsions
Crude Oil
Kerosene Limoid
Carbolic Acid
Whale Oil Soap
Caustic Soda
Tree Tanglefoot
XII. *Report of the Mosquito Investigation in 1906* 61
Jersey City Meadow
Newark
Elizabeth
Linden
Atlantic Highlands
Shrewsbury River
Staten Island
Arlington
Point-No-Point
East Orange
Orange Mountain Towns
New Durham
Lake Hopatcong
Mount Holly
Other Local Work
Culicide
Killarvae
Report on the Fish Experiments 65
Mosquitoes of the Season 65

NEW JERSEY AGRICULTURAL EXPERIMENT STATIONS

NEW BRUNSWICK, N. J.

1. STATE STATION. ESTABLISHED 1880.

BOARD OF MANAGERS.

EXCELLENCY EDWARD C. STOKES, LL.D., Trenton, Governor of the State of New Jersey.
L S. DEMAREST, D.D., . New Brunswick, President of the State Agricultural College.
ARD B. VOORHEES, Sc.D., . Professor of Agriculture of the State Agricultural College.

FIRST CONGRESSIONAL DISTRICT.
AIM T. GILL, . . . Haddonfield.
N W. BORTON, . . . Mullica Hill.

SECOND CONGRESSIONAL DISTRICT.
E. DARNELL, . . . Masonville.
ancy.)

THIRD CONGRESSIONAL DISTRICT.
D D. DENISE, Pres., . . Freehold.
S NEILSON, . . . New Brunswick.

FOURTH CONGRESSIONAL DISTRICT.
EL B. KETCHAM, V. Pres., Pennington.
R V. D. VAN DOREN, . Millstone.

FIFTH CONGRESSIONAL DISTRICT.
N WOODRUFF, . . . Elizabeth.
VIN S. CONDIT, . . . Boonton.

SIXTH CONGRESSIONAL DISTRICT.
ABRAM C. HOLDRUM, . . . Westwood.
HENRY MARELLI, . . . Paterson.

SEVENTH CONGRESSIONAL DISTRICT.
GEORGE E. DE CAMP, . . . Roseland.
CYRUS B. CRANE, . . . Caldwell.

EIGHTH CONGRESSIONAL DISTRICT.
GEORGE DOBER, ... East Orange.
JOSEPH B. WARD, M.D., . . Lyons Farms.

NINTH CONGRESSIONAL DISTRICT.
(Vacancy.)
JOHN HUDSON, ... Jersey City.

TENTH CONGRESSIONAL DISTRICT.
HENRY BELL, ... Union Hill.
HENRY A. GAEDE, . . . Hoboken.

STAFF.

EDWARD B. VOORHEES, Sc.D., . . Director.
IRVING S. UPSON, A.M., . . . Chief Clerk; Secretary and Treasurer.
MARY A. WHITAKER, ... Stenographer and Typewriter.
IRVING E. QUACKENBOSS, . . Assistant Clerk.

N P. STREET, M.Sc., Chemist.
CENT J. CARBERRY, Assistant Chemist.
CY E. BROWN, B.Sc., Assistant Chemist.
RGE H. BURTON, Laboratory Assistant.
TER H. WILLIAMSON, Sampler and Assistant.

JOHN B. SMITH, Sc.D., Entomologist.
GEORGE A. BILLINGS, B.Sc., Dairy Husbandman
GEORGE F. WARREN, Ph.D., Horticulturist.
JENNIE A. VOORHEES, A.B., Assistant Horticulturist.
GEORGE G. MANNING, Field and Greenhouse Assistant.

HARRY W. WILLIAMS, Janitor.

2. AGRICULTURAL COLLEGE STATION. ESTABLISHED 1888.

BOARD OF CONTROL.

The Board of Trustees of Rutgers College in New Jersey.

EXECUTIVE COMMITTEE OF THE BOARD.

L S. DEMAREST, D.D., President of Rutgers College, Chairman, . . . New Brunswick.
LIAM H. LEUPP, ... New Brunswick.
. HENRY W. BOOKSTAVER, LL.D., ... 24 East 64th Street, New York City.
ES NEILSON, ... New Brunswick.
L COOK, ... Troy, New York.
N W. HERBERT, Jr., ... Helmetta.

STAFF.

EDWARD B. VOORHEES, Sc.D., ... Director.
IRVING S. UPSON, A.M., ... Chief Clerk.
IRVING E. QUACKENBOSS, ... Assistant Clerk.

IUS NELSON, Ph.D., Biologist.
ON D. HALSTED, Sc.D., Botanist and Horticulturist.
LE J. OWEN, B.Sc., Assistant in Horticulture.
ZABETH R. NICHOLAS, Stenographer and Typewriter.

JOHN B. SMITH, Sc.D., Entomologist.
AUGUSTA E. MESKE, Stenographer and Typewriter.
JACOB G. LIPMAN, Ph.D., Soil Chemist and Bacteriologist.

THE COLLEGE FARM.

he Trustees of the College give the Stations the use of seven acres of land for experiments in iculture and Botany, and the remainder of the farm (90 acres), well stocked and equipped, for

His Excellency Edward C. Stokes, Governor of the State of New Jersey:

SIR—I have the honor to submit herewith the Twenty-seventh An-
l Report of the New Jersey State Agricultural Experiment Sta-
ı, as required by the law establishing the Station, which was ap-
ved March 10th, 1880, and which is chapter 106 of the laws of that
r.

DAVID D. DENISE,
President.

NEW BRUNSWICK, N. J., November 30th, 1906.

His Excellency Edward C. Stokes, Governor of the State of New Jersey:

SIR—In compliance with an act of Congress, approved March 2d,
7, and with an act of the Legislature of this State, approved March
, 1888, I beg leave to submit, on behalf of the Trustees of Rutgers
lege in New Jersey, maintaining Rutgers Scientific School, the
w Jersey State College for the benefit of Agriculture and Mechanic
s, the Nineteenth Annual Report of the operations of that depart-
ıt of the College which has been organized in accordance with said
of Congress, and is known as "The State Agricultural College Ex-
iment Station."

W. H. S. DEMAREST,
President.

NEW BRUNSWICK, N. J., November 30th, 1906.

TREASURER'S REPORT.

ving S. Upson, in account with the New Jersey State Agri- ural Experiment Station, November 1st, 1905, to October , 1906.

*Appropriation for Salaries and Expenses.

RECEIPTS.

State Treasurer	$20,000 00

PAYMENTS.

ies and Pay of Chemists and Assistants	$12,866 01
nses of Board of Managers	42 76
onery	226 49
ing	201 23
ge, Telephone and Telegraph Service	232 36
iture	381 73
	790 26
Electricity and Water	298 12
ratory Expenses	771 65
and Feeding Experiment Expenses	2,382 69
ht, Express and Cartage	136 85
nses Collecting Samples of Fertilizers	282 32
eling Expenses	136 55
ral Fittings, Repairs and Improvements	843 21
ance	181 49
ence Books	211 28
ingent Expenses	15 00
Total	$20,000 00

opriation for Carrying Out the Provisions of "An Act Concerning the Regulation of the Sale of Concentrated Commercial Feeding Stuffs."

RECEIPTS.

State Treasurer	$3,000 00

PAYMENTS.

ies and Pay of Chemists and Assistants	$2,543 26
ratory Fittings, Apparatus and Supplies	297 13
nses Collecting Samples of Feeding Stuffs	159 61
Total	$3,000 00

Appropriation for Printing Bulletins.

RECEIPTS.

From State Treasurer	$1,5

PAYMENTS.

For Printing Bulletins	$1,5

Appropriation for Carrying Out the Provisions of "An Act to Re[g] the Sale of Paris Green."

RECEIPTS.

From State Treasurer	$5

PAYMENTS.

Salaries and Pay of Chemists and Assistants	$2
Laboratory Fittings, Apparatus and Supplies	1
Printing	1
Total	$5

Appropriation for the Purpose of Carrying into Effect "An Act to [pro]vide a Method for Locating and Destroying Mosquito-breedin[g] Areas, Authorizing Appropriations for Said Purposes and Providing State Aid for Freeing Salt Marsh Areas from Mosquitoes."

RECEIPTS.

From State Treasurer	$3,5

PAYMENTS.

Salaries and Compensation of Assistants	$2,8
Labor	
Laboratory and Field Apparatus and Supplies	1
Freight and Express	
Traveling Expenses	4
Total	$3,5

The Auditing Committee of the Experiment Station ha[s] [ex]amined the accounts of the Treasurer of said Station, and found them correct.

GEORGE E. DECAMP,
SAMUEL B. KETCHAM,
Auditing Committe[e]

FINANCIAL STATEMENT.

The Trustees of Rutgers College
for
The New Jersey State Agricultural College Experiment Station
in account with
The United States Appropriation, 1905-1906.

RECEIPTS.

ı the Treasurer of the United States—	
.tch Act	$15,000 00
ams Act	5,000 00
	$20,000 00

DISBURSEMENTS.

	Hatch Act.	Adams Act.	
·ies	$10,250 00	....	$10,250 00
r	797 56	$33 00	830 56
cations	188 70	....	188 70
ıge and Stationery	769 82	....	769 82
ht and Express	72 27	....	72 27
. Light, Water and Power	333 70	....	333 70
ical Supplies	82 50	....	82 50
;, Plants and Sundry Supplies	210 55	23 65	234 20
lizers	90 00	165 10	255 10
ng Stuffs	....	....	....
ry	878 40	511 05	1,389 45
·, Implements and Machinery	7 48	84 45	91 93
iture and Fixtures	81 50	....	81 50
tific Apparatus	145 43	3,532 75	3,678 18
Stock	40 00	650 00	690 00
·ling Expenses	141 50	....	141 50
ngent Expenses	364 22	....	364 22
ings and Repairs	546 37	....	546 37
	$15,000 00	$5,000 00	$20,000 00

·, the undersigned, duly appointed auditors of the corporation, do hereby ·y that we have examined the books and accounts of the New Jersey State ultural College Experiment Station for the fiscal year ending June 30th, that we have found the same well kept and classified as above, and that ·ceipts for the year from the Treasurer of the United States are shown to been $20,000, and the corresponding disbursements $20,000, for all of ı proper vouchers are on file, and have been by us examined and found ·t, thus leaving no unexpended balance.

d we further certify that the expenditures have been solely for the purpose ·rth in the acts of Congress, approved March 2d, 1887, and March 16th,

(Signed) W. H. S. DEMAREST,
EDWARD B. VOORHEES,
Auditors.

REPORT OF THE DIRECTOR.

REPORT OF THE DIRECTOR.

The past year has witnessed a marked forward movement in the rk of both the State and College Stations. The passage of a ıte law, charging the Station with the inspection and analysis of ris green, has materially increased both the office and labora-y work, while the passage by Congress of the Adams act has adened the field of work of the College Station. The Adams supplements the Hatch act, and provides for an increase of ,000 in the annual appropriation to the Station for the year ling July 1st, 1906, and an annual increase of $2,000 until the al sum appropriated reaches $15,000. The funds provided by s act are to be used exclusively for scientific investigation, and, order to have this work separate and distinct, the Department Plant Breeding and the Department of Soil Chemistry and cteriology, have been transferred to this fund. This arrange-nt enables the Station to pursue the lines of investigation pre-usly established, and also to strengthen and enlarge all of the er departments of the Stations. The opportunity for field ek, as well as the equipment of the laboratories, have also been arged. The additional land, furnished by the College, pro-es ample areas for plot experiments in the Departments of l Chemistry and Bacteriology and in Plant Nutrition Studies, l for plant breeding and for forage crop experiments.

The work is well organized, and the departments are equipped carrying on purely scientific investigations, as well as to prop-; prosecute the various lines of inspection. The detailed work the various departments for the past year will be found in the letins and in the regular reports herewith of the officers in rge.

Examination of Fertilizers.

In the prosecution of the fertilizer control, 430 samples of co plete fertilizers, representing 102 manufacturers, were analys The results of these analyses show a greater deficiency in element nitrogen than in phosphoric acid and potash; a tenden also, very noticeable in the work of last year. When the gu antee is not reached, it is the custom of the chemical laborat to duplicate analyses, and to make a preliminary report of results secured to manufacturers, in order that they may be vised of the results secured previous to the publication of bulletin.

For many years the Station has published the selling pri of the fertilizers attached to the brand analysed, assuming it be a fair guide as to the prices that consumers pay. There however, such a wide variation in the selling prices of the sa brand in different parts of the State that this year the selli prices have been omitted.

Incomplete Fertilizers and Special Mixtures.

In addition to the number of complete fertilizers analysed, the were 205 samples examined, representing home mixtures, special prepared mixtures, fertilizer materials and ground bones. Th results of these analyses, on the whole, show very clearly th advantage to the farmer of purchasing supplies from origin sources. This method of purchase has been made a matter c special study by the Station in the past, and the results secure this year simply confirm the suggestions made heretofore as t the advantages to be derived both in reducing the cost per poun of the constituents and in obtaining them in the best forms There is no real advantage afforded the farmer by an opportunit for selection from so large a number of brands of complete fer tilizers as are now on the market; the profitable returns from their use are usually due to the amounts supplied, rather than to special relations that exist between the different constituents Bulletins Nos. 196 and 198 contain the results of these inspec tions, and will not be incorporated in the annual report.

Commercial Feeds.

Three hundred and eighty-four samples of commercial feeds were collected, of which 348 samples were analysed. The samples requiring guarantee represented 125 different brands, a number considerably lower than was the case last year. Four of these brands were devoid of all information as to their composition, which is 3.2 per cent. of the total number, the best showing of any previous inspection. No adulterations were observed, but a number of feeds of inferior quality were found. Seventeen feeds new to the State were examined; of these, the alfalfa are the most important. The value of the Station's work along this line is greatly appreciated by our own farmers, feed dealers and manufacturers, as well as by those in other States. This is due, in part, to the fact that the work is not confined to a mere inspection, but includes a real study of the whole feed problem, and possesses educational as well as commercial value, and is thus in many ways of permanent service to those interested in the subject. Bulletin No. 193, containing the results of this inspection, was issued in March.

Miscellaneous Samples.

In addition to the feeds and fertilizers analysed, fifty-seven samples were examined, either in connection with the investigations in other departments, or for the purpose of determining the value of waste products, either for use as fertilizers, feeds or soil amendments.

Paris Green.

Thirty samples were obtained, representing both manufacturers and dealers. The results of this inspection show that the majority of the brands offered are of good quality. The requirements of the law are moderate, and with reasonable care in the manufacture should reach the standard fixed by the law. Bulletin No. 195, issued in September, contains the analyses of the samples secured, together with other information of value to consumers.

Chemical Investigations.

During the past year much time has been given to a study the carbohydrate group of nutrients, and valuable data w secured as to the variability of the substances contained there besides indicating that inaccuracies exist in the present meth of determining starch, pentosans and crude fiber. In connect with this work an examination was made of distillers' grai alfalfa meal and cottonseed meal, which confirmed the fact tl the crude fiber secured by the official method is impure, being cc taminated with ash, nitrogenous substances, pentosans and lign bodies.

In this department, also, a method was worked out for the ide tification of peat in commercial fertilizers, a matter which m be of some importance in view of the possible use of this substan as a drier in fertilizer mixtures and materials.

Co-operative work with the Association of Official Agricultur Chemists was, also, carried on in this department for the purpo of determining the availability of organic nitrogen in fertilize and the preparation of standards of composition of buckwhea sorghum and millet products, as well as those animal product used for feeding animals and poultry. Mr. William P. Aller assistant chemist, resigned September 1st to take a responsibl position with the Du Pont Powder Works.

Plant Nutrition.

The studies in this department have been a continuation of those previously reported, no addition having been made to the plant nor changes in the plan. The data obtained from the cylinder experiments have a cumulative value; with the crop of timothy now growing it is believed that the primary purpose of this experiment will have been accomplished, when the plan will be changed, in order to study other phases of the subject. The new pot system for conducting experiments, reported last year, is giving good satisfaction again this year, making it possible to make soil tests rapidly and accurately. Thus far the results show that soils of the red-shale type are deficient in phosphoric acid for both cereal and leguminous crops.

Soil Chemistry and Bacteriology.

The ammonification studies reported in 1905 were continued, and a further test was made of various culture media and their application in the investigation of bacteriological factors in soil fertility.

An attempt to differentiate the chemical and bacteriological factors in the ammonification of soil nitrogen furnished ample proof that the chemical constitution of the soil has a direct influence, not only on the numbers, but also on the physiological efficiency of its bacteria, and that the bacteriological properties of soils are a function, therefore, of the chemical composition of the soil and of the organisms present in it. The peptone solutions used by the German bacteriologists in the study of ammonification was replaced by gelatin, and it was found that the latter is in many respects a more suitable medium and better calculated to bring out certain biological differences in soils. It was shown with the aid of these media that the addition of lime to the soil increases its ammonifying power, the increase bearing a certain relation to the amounts of lime added. The results secured here encourage the belief that a bacteriological method may thus be devised which will prove of great value in the study of the lime requirements of soils.

Apart from the bacteriological studies in the laboratory, the soil chemist and bacteriologist has continued jointly with the director, the cylinder, pot and box experiments referred to elsewhere. All of these involved about 2,500 nitrogen determinations, in addition to other analytical work. A large number of soil samples sent in from different parts of the State were also examined, and advice was given as to their proper fertilizer treatment, crop rotation, &c.

Farm and Dairy.

The soiling crop experiments carried out on the farm have been continued, though enlarged in their scope, owing to the larger experiment area now available. Different varieties of cow peas and soy peas were studied, both in reference to their usefulness as forage and as seed crops, and very marked differences were observed in the various varieties in these respects. The alfalfa

experiments were also continued, and new seedings have bee made this fall.

An experiment was also planned to test the relative advantage of phosphoric acid derived from basic slag and acid phosphate.

Comparative feeding experiments were conducted this year witl dried distillers' grains, with gluten feed, with alfalfa hay as a substitute for concentrated feeds, and summer silage and soiling crops. The results of these experiments will be published in bulletin form. They show that distillers' grains are a very excellent source of protein, that the entire substitution of alfalfa hay for fine feeds is not as satisfactory as a mixture of hay and small amounts of fine feed, though on the basis of cost of production making a much cheaper ration, and that the feeding of silage in summer is entirely practical, and may in part, if not altogether, substitute pasturage or soiling.

Experiments were also made to show the relative value of cow peas and crimson clover compared with manure as a preparatory treatment for succeeding crops of corn and wheat.

HORTICULTURE.

In this department the work on the experiment grounds and in the plant-houses has been continued along the usual lines by the assistant horticulturist. The experiments with different fertilizers upon asparagus, blackberries, raspberries, gooseberries, currants and peaches, having been carried on continuously for ten years, the final results and summaries are recorded this year.

The work of the horticulturist has included a study of the conditions in reference to spraying, and the results of his observations are recorded in Bulletin No. 194, issued in March. Bulletin No. 197, issued in September, entitled "The Peach Industry in New Jersey," contains many recommendations of value as a result of a detailed study of the conditions and possibilities of the industry in this State. This bulletin should give much encouragement to growers, as it shows very distinctly the natural advantages of soil, climate and location possessed by the State, and that the disadvantages may be readily overcome if good business methods are employed, and attention is given to the matter of spraying. An experimental orchard was established in Hunterdon county to

study in detail all the problems connected with peach growing. A beginning has also been made in the study of the apple industry of the State.

Much attention has also been given to the question of improved varieties of asparagus, a growing and profitable industry in this State. Mr. George F. Warren, the horticulturist, resigned his position here October 1st to accept the position of Assistant Agronomist in Cornell University.

BIOLOGY.

The experimental study of oyster propagation is the chief line of inquiry. The season's work was introduced by the erection and equipment of a laboratory near Barnegat, which enabled the biologist to conduct experiments upon what is practically a natural oyster-bed. The oyster-fry cages instituted last year were again tried, but in an area of fresher water. The extraordinary wetness of the summer caused the water to become too fresh for conclusive results along this line.

Comparative experiments in the planting of oyster cultch were instituted, and observations were made on the natural spatting. Most promising results were obtained, which will prove of great value in directing future operations in this line of study.

A new line of inquiry was started in the study of the effect of environment on the maturation of the reproductive cells of the adult oyster. Several of the rules for the successful manipulation of fertilization tests were amended and perfected. Thus it was discovered that the ova develop more perfectly if they are washed before the sperms are added than if the process is performed after fertilization.

A new Station was also chosen, and preliminary experiments instituted upon Mullica river, near the famous "gravelling" natural seed-beds. This region appears very promising as a field for oyster research work. The experiment on egg production begun last year was continued, and an experiment to test the von Behring method for rendering young cattle immunize against tuberculosis was begun.

BOTANY.

In the botanical department the work for the year 1906 has be chiefly that of the improvement of truck crops by breeding ar selection.

Among the subjects receiving the most attention are: Bean corn, eggplants, squashes and tomatoes, while, in a small wa martynias, okra, onions, peas, peppers, salsify, udo and sever strains of Chinese vegetables have been included.

The number of crosses of beans already secured is large; wit some of them the types are becoming fixed, and there is promis of producing prolific, stringless, snap sorts, with fleshy pods bea ing small white seeds. Many crosses have likewise been obtaine among the lima beans and certain ones between the "Jackso Wonder" and the "Burpee" types are desirable. Owing to th prevalence of mildew, which is favored by the surrounding dens foliage, efforts are being made to secure types associated with th "willow-leaf" form of foliage and with a longer flower stem tha the pods may be borne above the leaves. The hybrids of th "Scarlet Runner" and bush beans have proved of much interes in their second generation, and there is hope of securing types o much value.

A large number of plots of sweet corn have been grown and at least two crosses seem sufficiently desirable to warrant the distribution of seeds under their respective names.

Among the crosses of eggplants grown the past season the most promising have been a sort with a white flesh and a pink exterior and another with the same character of flesh, but with a white surface. The work of hybridizing the "America" and "Chinese" species is progressing, and some information obtained may aid in understanding the general subject of breeding.

Forty lots of crossed summer squashes have been grown, and the results thus far obtained inspire hope in the attempt to fix new and desired types in this vegetable fruit. Among the vine squashes various crosses and hybrids have been grown, some of which appear to be worthy of further consideration.

Tomatoes have occupied a large portion of the space in both greenhouse and garden, and among the hundreds of crosses some have attracted much atention, from which seed has been saved for

urther trial. One combination of special merit of "Marvel" and Ponderosa," called the "Marvelosa," is added to the list of those lready developed.

The work with peas was taken up the past season with the hope f securing, for example, a small early sort, now much needed by e canners of the State.

During the year two bulletins, namely, No. 191, "Seed Distriution of 1904 and for 1905," and No. 192, "Breeding Sweet orn—Co-operative Tests," have been issued, the last one of hich deals with certain laws of breeding determined with corn, nd may prove to be widely applicable to other vegetable fruits.

The seed distribution of last spring embraced 1,332 packets, s follows: Lima beans, 112; sweet corn, 329; eggplants, 267; quashes, 216, and tomatoes, 408 packets, respectively.

A branch for seed inspection has been opened, and the offer is ade to examine samples of clover and allied seeds as to their urity.

ENTOMOLOGY.

In the entomological department the planned work of the eason included primarily a study of the root-maggots infesting nion and cruciferous crops, less with the view of finding out ew facts in the life cycle than to determine what practical ethods of checking or preventing injury were available. While ese studies have not been concluded, enough has been learned authorize a preliminary bulletin, which will be prepared during e winter. The occurrence of brood VIII., of the Periodical icada, gave opportunity to study the changes in seventeen years, is same brood having occurred in 1889, when the present entoologist was first appointed. Incidentally, the other species occurng in the State were studied and will be reported upon.

Practical experiments with insecticides were continued in rious parts of the State and a special study of arsenate of lead nd its action and of the soluble oils was carried on. Some acunt of the methods of manufacture of the latter is presented.

A large number of observations were made upon the results of ractical work carried on against the pernicious scale throughout e State, and, as a result of a better understanding of the object be aimed at, a very great lessening of the pest can be recorded.

The insect is no less widespread than before, but the method dealing with it is much better understood.

Close relations with the shade-tree commissioners of our lar cities have been maintained, with the result that, as a rule, c trees have been in much better condition than ever before, and has been shown that it is practical and not greatly expensive avoid serious insect injury.

The spread of the Gypsy and Brown-Tail Moths has been clos observed, and two reports of its occurrence within the State h been investigated.

Besides these main lines of work, numerous other studies a observations were made, some of which will be noted in the ann report.

The mosquito work, which is also in the hands of the entomo gist, has consisted of observations and experiments looking to t completion of the life history of those species which were not fully known; of surveys of areas, where improvements were c templated along the shore; of making investigations requested local boards of health; of preparing drainage maps of marsh near the larger centers of population; of introducing the t minnow from the Southern States into our own waters, and testing some of the remedies proposed for the extermination adults or larvæ.

Farmers' Meetings.

The policy of the Stations, as in the past, has been to keep close touch with the various farming interests, the officers visiti the different sections to familiarize themselves with the con tions, in order that they may give better advice in regard to t improvement in methods, and to note progress of experimen Many members of the staff also take part in the farmers' me ings throughout the State, and lecture at the Farmers' Institu —they take advantage of every opportunity to bring the work the Station directly to the attention of the farmer. The adva tages of such work are apparent in the reliance placed on t advice based upon science, besides the knowledge gained by t officers in reference to the special needs, enables them to plan a carry out more comprehensive and valuable experiments.

Correspondence.

The Station also serves as a bureau of information, the cor- spondence in all of the departments increasing as the knowledge the helpfulness of the work of the Station is spread throughout e State. This requires a large amount of time daily in the rious offices, but is a very helpful line of work, though not of ch a character as to be readily incorporated in the annual report.

Equipment.

Aside from the addition of land made available for experiments, e departments have all been made more efficient by the addition scientific appliances and apparatus. In the Departments of ant Breeding and Soil Chemistry and Bacteriology very large ditions to the equipment have been made. It is the aim of the icers to keep well abreast of the times, in respect to new and proved apparatus and appliances, in order that advanced work y be prosecuted in the most scientific manner.

The library is well supplied with all the important technical rks, standard journals and periodicals, and many additions are nually made. The files of Station literature are kept up-to-date, creasing materially the work of the office force.

The director desires to make record of his appreciation of the yal co-operation, and the efficient and faithful services of all icers and assistants.

REPORT OF THE CHEMISTS.

REPORT OF THE CHEMISTS.

I. Inspection of Commercial Fertilizers.
II. The Detection of Peat in Commercial Fertilizers.
III. Inspection of Concentrated Feeds.
IV. The Carbohydrates of Dried Sugar Beet Pulp.
V. Note on the Determination of Crude Fiber.
VI. Buckwheat Products: Standards of Composition.
VII. Inspection of Paris Green.
VIII. Investigations Relative to the Use of Nitrogenous Materials.
IX. Plant Nutrition Studies.
X. Field Experiments.

I.

Inspection of Commercial Fertilizers.

The inspection this year has required the following analyses

436	Samples of	Complete Commercial Mixtures.
34	"	Ground Bone.
101	"	Fertilizing Raw Materials.
7	"	Home Mixtures.
27	"	Specially Compounded Mixtures.
35	"	Sundry Materials.

The results of the inspection were published in Bulletins 196 and 198, a summary of which follows:

Summary.

All the brands examined this year were accompanied by a guarantee, as required by law, with the exception of two complete fertilizers, seven ground bones, and one dissolved bone.

The quality of the fertilizers was excellent with but few exc tions: in 279 samples of complete fertilizers nitrogen was fou in the form of nitrates, in 128 in the form of ammonia sal while in 91 samples both of these soluble forms were present quantities exceeding 0.20 per cent.; 38 per cent. of the tot nitrogen was in the water-soluble form.

There were 278 failures to reach guarantee distributed amo 224 brands, 48 being deficient in two and three brands in a three ingredients. The number of deficiencies was 21.3 per cen of those possible, a much higher proportion than observed i any of the Station's previous inspections. The average valu tion of complete fertilizers was $21.28 per ton, and the averag selling price $28.12, a difference of $6.84, or 32.1 per cent.

Manufacturers

WHOSE GOODS HAVE BEEN SAMPLED AND ANALYSED THIS YEAR.

J. H. Allen & Son........Lawrence Station, N. J
Alexandria Fertilizer & Chemical Co........Alexandria, Va
American Agricultural Chemical Co........26 Broadway, New York City
Bradley Branch........92 State St., Boston, Mass
Chemical Co. of Canton Branch........32 S. Charles St., Baltimore, Md
Chicopee Guano Branch........82 Wall St., New York City
Clark's Cove Branch........81 Fulton St., New York City.
Crocker Branch........56 Pearl St., Buffalo, N. Y.
Detrick Branch........Baltimore, Md.
East India Branch........93 William St., New York City.
Great Eastern Branch........Rutland, Vt.
Milsom Branch........963 William St., E. Buffalo, N. Y.
Pacific Guano Branch........27 William St., New York City.
Packers' Union Branch........150 Nassau St., New York City.
Moro Phillips Branch........710 Bourse, Philadelphia, Pa.
Preston Branch........Greenpoint, L. I., N. Y.
Quinnipiac Branch........83 Fulton St., New York City.
Read Branch........16 Exchange Place, New York City.
Sharpless & Carpenter Branch........710 Bourse, Philadelphia, Pa.
Tygert-Allen Branch........2 Chestnut St., Philadelphia, Pa.
Wheeler Branch........Rutland, Vt.
Williams & Clark Branch........27 William St., New York City.
Zell Branch........Baltimore, Md.
Armour Fertilizer Works........Baltimore, Md.
Warren Atkinson........Mullica Hill, N. J.
J. H. Baird........Marlboro, N. J.

. A. Ballenger........ Mullica Hill, N. J.
attelle & Renwicke........ 163 Front St, New York City.
augh & Sons Co........20 S. Delaware Ave., Philadelphia, Pa.
each Soap Co........Lawrence, Mass.
. A. Bennett ....Robbinsville, N. J.
he Berg Co........ Russell and Bath Sts., Philadelphia, Pa.
owker Fertilizer Co........43 Chatham St., Boston, Mass.
. F. Brooks & Co........Philadelphia, Pa.
. E. Brown........Red Bank, N. J.
'm. M. Brown........Cedarville, N. J.
. C. Clark & Son........ Mt. Ephraim, N. J.
he Coe-Mortimer Co........133 Front St., New York City.
ohn S. Collins & Son........Moorestown, N. J.
ollins & Pancoast........Neshanic, N. J.
eter Cooper Co........New York City.
. F. Demaris & Son........Cedarville, N. J.
enise & Denise........ Freehold, N. J.
. Dougherty........Philadelphia, Pa.
. W. Doughten........ East Moorestown, N. J.
as. C. Downward Co........ Coatesville, Pa.
agle Guano Co........New York City.
. C. Fifield & Sons Co........Bakersville, N. J.
he Flavel Co........Asbury Park, N. J.
laser Fertilizer Co........Plainfield, N. J.
/. R. Grace & Co........1 Hanover Square, New York City.
as. C. Griscom........Woodbury, N. J.
endrickson & Dilatush........Robbinsville, N. J.
M Hess & Bro........Fourth and Chestnut Sts., Philadelphia, Pa.
acob V. Higgins........Flemington, N. J.
aretta Hill........ Copper Hill, N. J.
ill & Co........Flemington, N. J.
ires & Co .... Quinton, N. J.
. Hoffman & Bro........Raulsville, Pa.
he Hubbard Fertilizer Co........Baltimore, Md.
nternational Seed Co........Rochester, N. Y.
H. Ivins........Collingswood, N. J.
ambertson & Hance ....Freehold, N. J.
amuel Lederer & Sons........New Brunswick, N. J.
ieber Bros........Atlantic City, N. J.
. A. Lippincott & Bro........Moorestown, N. J.
ister's Agricultural Chemical Works .... Newark, N. J.
rederick Ludlam Co........81 New St, New York City.
he Mapes F. and P. Guano Co........143 Liberty St., New York City.
he D. B. Martin Co........ Broad and Chestnut Sts., Philadelphia, Pa.
he Mathieson Alkali Works........Saltville, Va.
ichigan Carbon Works........Detroit, Mich.
ohn E. Minch........Bridgeton, N. J.
inch Bros ....Bridgeton, N. J.
onmouth Chemical Works........ Shrewsbury, N. J.

Jos. R. Moore .... Swedesboro, N. J
L. Moritz .... 1321 North Fifth St., Philadelphia, Pa.
Nelson Morris Co .... Chicago, Ill.
Muzzy Bros .... Paterson, N. J.
Nassau Fertilizer Co .... 5 Beaver St., New York City.
Albert Nelson & Co .... Allentown, N. J.
Northwestern Fertilizer Co .... Chicago, Ill.
James E. Otis .... Tuckerton, N. J.
S. L. Pancoast .... Mullica Hill, N. J.
S. Frank Pennell .... Bridgeton, N. J.
Peterson & Smith .... Woodstown, N. J.
Pittsburg Provision Co .... Pittsburg, Pa.
Quaker City Poudrette Co .... Philadelphia, Pa.
Rasin-Monumental Co .... Baltimore, Md.
John Repp .... Glassboro, N. J.
Enos Richmond .... Elmer, N. J.
Edward Rigg, Jr .... Burlington, N. J.
M. F. Riley .... Elmer, N. J.
Rogers & Hubbard Co .... Middletown, Conn.
Ruckman Bros .... New Brunswick, N. J.
Scott Fertilizer Co .... Elkton, Md.
Sharpless & Bro .... Camden, N. J.
J. E. Sherman .... Frenchtown, N. J.
M. L. Shoemaker & Co .... Delaware Ave. and Venango St, Philadelphia, Pa.
Jos. Smith & Co .... Stockton, N. J.
R. W. Smith .... Elmer, N. J.
Swift & Co .... Chicago, Ill.
Wm. Taubell Hosiery .... Riverside, N. J.
G. F. Taylor Co .... New York City.
The Taylor Provision Co .... Trenton, N. J.
Taylor Bros .... Camden, N. J.
I. P. Thomas & Son Co .... 2 S. Delaware Ave., Philadelphia, Pa.
Trenton Bone Fertilizer Co .... Trenton, N. J.
F. W. Tunnell & Co .... 15 N. Fifth St., Philadelphia, Pa.
The J. E. Tygert Co .... 28 S. Delaware Ave., Philadelphia, Pa.
A. J. Vreeland .... Matawan, N. J.
Jos. K. Waddington .... Salem, N. J.
Emil Wahl Manufacturing Co .... Philadelphia, Pa.
F. K. Walt Co .... Reading, Pa.
Geo. M. Wells .... Moorestown, N. J.
J. Wenderoth & Sons .... Camden, N. J.
West Jersey Marl and Transportation Co .... Woodbury, N. J.
John Whann & Son .... Philadelphia, Pa.
W. E. Whann .... William Penn, Pa.
Winterbottom, Carter & Co .... Egg Harbor City, N. J.
Woodward & Dickerson .... Philadelphia, Pa.

MONTHS. 1905.	OF NITROGEN IN FORM OF—						OF PHOSPHORIC ACID IN FORM OF—		OF POTASH IN FORM OF—							
	Nitrate of Soda.		Sulphate of Ammonia.		Dried Blood.		Acid Phosphate.		Kainit.		Muriate of Potash.		Double Sulphate of Potash and Magnesia.		High-Grade Sulphate of Potash.	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.
January	15.0	14.9	15.7	15.5	16.3	16.0	3.4	3.0	3.8	3.6	3.8	3.7	4.4	4.3	4.4	4.3
February	15.0	14.9	16.2	16.0	15.9	15.6	3.4	3.0	3.6	3.5	3.8	3.8	4.5	4.3	4.4	4.4
March	15.0	14.9	15.6	15.6	15.5	15.2	3.4	3.0	3.4	3.4	3.9	3.9	4.6	4.5	4.6	4.5
April	15.9	15.8	15.4	15.3	16.1	15.8	3.4	3.0	3.4	3.4	3.9	3.9	4.6	4.5	4.6	4.5
May	17.5	16.5	15.3	15.1	16.1	15.8	3.4	3.0	3.4	3.4	3.9	3.9	4.6	4.5	4.6	4.5
June	15.3	15.1	15.1	14.9	16.1	15.8	3.4	3.0	3.4	3.4	3.9	3.9	4.6	4.5	4.6	4.5
July	15.1	14.9	15.1	15.0	16.1	15.8	3.4	3.0	3.4	3.4	3.9	3.9	4.6	4.5	4.6	4.5
August	14.4	14.2	15.0	14.8	16.1	15.8	3.4	3.0	3.4	3.4	3.9	3.9	4.6	4.5	4.6	4.5
September	14.2	14.0	15.2	15.0	16.1	15.8	3.4	3.0	3.4	3.4	3.9	3.9	4.6	4.5	4.6	4.5
October	14.1	13.9	15.4	15.2	16.1	15.8	3.4	3.0	3.4	3.4	3.9	3.9	4.6	4.5	4.6	4.5
November	14.2	14.0	15.5	15.2	16.1	15.8	3.4	3.0	3.4	3.4	3.9	3.9	4.6	4.5	4.6	4.5
December	14.1	14.0	15.2	15.0	16.1	15.8	3.4	3.0	3.4	3.4	3.9	3.9	4.6	4.5	4.6	4.5
Average, for 1905	**14.9**		**15.0**		**15.8**		**3.2**		**3.4**		**3.9**		**4.5**		**4.5**	
Average, for 1904	**14.1**		**15.2**		**15.5**		**3.2**		**3.7**		**3.8**		**4.5**		**4.2**	
Average, for 1903	**13.2**		**15.2**		**15.8**		**3.2**		**3.7**		**3.8**		**4.5**		**4.3**	

Wholesale Prices of Fertilizing Ingredients for 1905.

The wholesale prices of crude products or raw materials quoted every Monday in the well-known trade journal *Oil, Paint and Drug Reporter.* These prices have been ta lated for the entire year, and have been recalculated in orde express them as prices per pound of actual plant-food, which the form adopted by the Experiment Stations of this coun On account of the fact that the report of the Station is m upon October 30th of each year, the results which app here in tabular form are for the year 1905. During the y the prices fluctuated very little, except in the case of nitrat soda and sulphate of ammonia, which reached their maxim in the spring months. As it is probably towards the close of year that the manufacturers of mixed goods place their contr for raw materials, the quotations for the last four months 1905 and the first two months of 1906 have been averaged a more suitable basis for the determination of the schedule valuations for 1906:

Schedule of Trade Values Adopted by Experiment Stations for 1906.

	Cents per p
Nitrogen in Nitrates	16.5
" " Ammonia Salts	17.5
Organic Nitrogen in dried and fine-ground fish, meat and blood, and in mixed fertilizers	18.5
" " " fine-ground bone and tankage	18.0
" " " coarse bone and tankage	13.0
Phosphoric Acid, soluble in water	4.5
" " " " ammonium citrate*	4.5
" " insoluble in fine bone and tankage	4.0
" " " " coarse bone and tankage	3.0
" " " " mixed fertilizers	2.0
" " " " fine-ground fish, cottonseed meal, castor pomace and wood ashes	4.0
Potash, as Muriate	4.25
" " Sulphate, and in forms free from muriates (or chlorids)	5.0

*The solubility of phosphates, in ammonium citrate solutions, varies with the degree of An act of the Legislature (see Laws of New Jersey, 1874, page 90) provides that in this determ tion the temperature used shall not exceed 100° Fahr.; in other States 150° Fahr. has adopted. Consequently the Station valuation of phosphoric acid, soluble in ammonium cit has been fixed at *four cents* per pound for Connecticut, Massachusetts, New York, Rhode Is and Vermont, and at *four and one-half cents* per pound in New Jersey.

Average Analyses of Fertilizing Materials.

Since the establishment of this Station a large number of analyses have been made of agricultural chemicals, refuse materials, guanos, phosphates, ashes, animal excrement, etc. These have been published from time to time in the Annual Reports, but for convenience of reference they are now collected here. In the tables which follow will be found the average, and, where more than one analysis has been made, the maximum and minimum percentages found of the essential plant-food ingredients, nitrogen, phosphoric acid and potash. Where determined, the form of the nitrogen and the phosphoric acid is also shown. While in all cases the essential ingredients have been determined and are here reported, a blank under any non-essential does not necessarily imply the absence of that constituent. In addition to the materials sold regularly for fertilizing purposes, the tables contain a number of analyses of fruit leaves, fruit tree prunings, and the vines of several of the more important vegetables.

The tables include 174 different materials, and represent 3,462 analyses:

Number of Analyses.	FERTILIZING MATERIAL.	Moisture.	NITROGEN.			PHOSPHORIC ACID		
			Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.
1	Alcohol waste, wood	....	....	....	....	....	....	0.0
119	Ammonia, sulphate of	....	21.20	16.26	20.46	....	....	....
30	Ammonite	....	14.23	10.07	11.96	5.84	1.17	3.01
1	Ashes, apple pomace	....	....	....	....	....	....	6.8
1	" bog	....	....	....	....	....	....	2.21
5	" cottonseed hull	....	....	....	....	10.76	7.92	9.5
2	" crematory	....	....	....	....	15.39	6.70	11.0
1	" hemlock	....	....	....	....	....	....	2.0
1	" hickory	....	....	....	....	....	....	1.6
1	" licorice root	....	....	....	....	....	....	0.7
3	Ashes, lime-kiln	....	....	....	....	1.64	1.13	1.37
1	" muck	....	....	....	....	....	....	7.74
1	" oak	....	....	....	....	....	....	2.4
5	" leached wood	....	....	....	....	1.88	0.15	0.74
78	" unleached wood	....	....	....	....	2.48	0.91	1.51
9	Basic slag	....	....	....	....	20.48	17.81	19.09
111	Blood, dried	....	14.58	7.31	11.99	7.68	0.00	0.89
1	" meat and bone	....	....	....	2.23	....	....	22.97
3	Bone, ash	....	....	....	....	18.18	17.13	17.82
44	" button	....	4.35	2.69	3.51	27.02	21.62	25.04
3	Bone, degelatinized	....	1.33	1.14	1.22	29.32	27.22	28.37
61	" dissolved	....	4.18	1.32	2.57	21.90	10.97	16.38
537	" raw ground	....	6.98	1.18	3.62	28.65	10.54	22.59
1	" residue	....	....	....	0.09	....	....	36.06
75	" steamed	....	3.43	0.74	2.05	32.86	21.90	27.77
2	" and meat	....	2.17	1.90	2.04	11.67	6.40	9.04
1	Bonora, dry	....	....	....	15.20	....	....	4.82
1	" liquid	....	....	....	5.65	....	....	2.22
1	Broom-corn seed	8.88	....	....	1.71	....	....	0.72
7	Castor pomace	....	6.19	4.15	5.44	2.20	1.73	1.99
1	Clay, nitrate-bearing	3.40	....	....	1.00	....	....	0.16
1	Cocoanut shells	9.55	....	....	0.12	....	....	0.20
2	Corena settlings	....	2.36	0.14	1.25	1.28	0.79	1.04
1	Cottonseed hulls	....	....	....	0.69	....	....	0.56
48	" meal	7.67	7.69	3.81	6.63	4.77	1.71	2.92
1	Cracklings	....	....	....	13.22	....	....	....
1	Dynamite By-Product	....	....	....	0.05	....	....	0.08
1	Feather refuse	....	....	....	14.76	....	....	....

POTASH.			NITROGEN.			PHOSPHORIC ACID.				
Maximum.	Minimum.	Average.	Nitrates.	Ammonia.	Organic.	Soluble.	Reverted.	Insoluble.	Lime.	Magnesia.
		0.05							41.54	
				20.46						
					11.96					
		11.33								
		0.41							7.23	
30.46	20.52	26.55				1.40	6.61	1.58		
2.08	1.81	1.95							22.00	
		3.67							54.52	
		4.56							36.29	
		0.07							28.00	
3.61	0.54	1.92							41.47	
		0.22					1.02	6.72	0.34	
		9.37							29.65	
1.89	0.16	0.69							28.75	
8.81	2.17	4.84							32.80	
							5.44	13.65	[1]49.68	
					11.99					
					2.23	*0.26*	*6.84*	*15.87*		
						16.75	0.75	0.32		
					3.51		6.33	18.71		
				0.46	0.76		15.30	13.07		
						5.63	6.53	4.22		
					3.62		7.70	14.89		
					0.09	0.52	33.28	2.26		
					2.05		7.33	20.44		
					2.04	6.78	0.90	1.36		
		4.68	4.88	10.32		4.82				
		1.81	*1.89*	*3.76*		*2.22*				
		0.52			1.71					
					5.44					
		0.18	1.00							
		0.32			0.12					
0.62	0.00	0.31			1.25					
		1.08			0.69					
2.30	1.49	1.82			6.63					
					13.22					
		0.27			0.05				34.22	
					14.76					

[1] One analysis.

Number of Analyses.	FERTILIZING MATERIAL.	Moisture.	NITROGEN. Maximum.	NITROGEN. Minimum.	NITROGEN. Average.	PHOSPHORIC A[CID] Maximum.	PHOSPHORIC A[CID] Minimum.	
29	Fish, crude	....	6.47	2.18	4.46	8.49	2.38	[illegible]
191	" dried	....	11.40	4.36	7.86	12.31	3.19	[illegible]
4	Floats	....	....	....	....	42.40	26.44	30
1	Flue dust	....	....	....	0.08	....	....	1
2	Garbage refuse	....	0.39	0.00	0.20	2.22	2.07	2
1	Guano, bat, California, dried	....	....	....	1.90	....	....	17
1	" " Mexico	....	....	....	2.77	....	....	5
1	" " Texas	....	....	....	11.76	....	....	3
1	" Carib	....	....	....	....	....	....	18
1	" Cayman Island	....	....	....	....	....	....	25
5	Guano, Chincha	....	8.46	7.29	7.91	10.66	9.37	10
7	" Lobas	....	3.30	2.72	3.09	22.07	18.12	19
7	" Orchilla	....	....	....	....	19.34	15.70	17
1	" Penguin Island	....	....	....	....	....	....	21
19	" Peruvian	....	8.46	2.72	5.36	22.07	9.37	15
1	Hair, dissolved	....	....	....	4.41	....	....	5
8	" waste	....	10.48	2.91	6.01	4.49	0.52	2.
1	Hemp waste	....	....	....	0.57	....	....	0.
5	Hoof meal	....	15.11	12.52	13.72	....	....	0.
1	Horn meal	....	....	....	14.85	....	....	Tr
2	Horse meat	....	8.87	7.69	8.28	4.37	4.25	4.
1	Hosiery waste	....	....	....	1.46	....	....	0.
1	Iron tailings	....	....	....	....	....	....	25.
146	Kainit	....	....	....	....	....	....	....
1	Kiln dust	....	....	....	4.46	....	....	1.
14	King crab	....	10.56	6.78	9.27	2.08	0.91	1.
3	Leather, raw	....	7.56	7.50	7.54	....	....	....
1	" steamed	....	....	....	6.87	....	....	....
1	" treated	....	....	....	7.22	....	....	....
10	Leaves, apple	....	1.19	0.79	0.97	0.21	0.13	0.
10	" cherry	....	0.82	0.34	0.55	0.24	0.10	0.
10	" peach	59.23	1.71	0.70	1.18	0.36	0.14	0.
20	" pear	....	1.38	0.51	0.88	0.38	0.15	0.
20	" plum	....	1.16	0.43	0.76	0.38	0.11	0.
9	" quince	....	1.11	0.58	0.88	0.29	0.10	0.
1	Licorice residue	56.07	....	....	0.69	....	....	....
1	Lime, blue	....	....	....	....	....	....	....
1	" gas	....	....	....	0.59	....	....	....

POTASH.		NITROGEN.			PHOSPHORIC ACID.				
Minimum.	Average.	Nitrates.	Ammonia.	Organic.	Soluble.	Reverted.	Insoluble.	Lime.	Magnesia.
...	...	...	...	4.46	...	...	...	...	...
...	...	...	...	7.86	...	...	...	...	...
...	...	...	...	...	...	2.08	34.51	...	...
...	...	...	...	0.08	...	0.25	1.00	...	...
1.17	1.32	...	...	0.20	...	...	...	7.92	...
...	6.27	...	0.20	1.61	3.04	9.62	4.48	...	...
...	0.52	2.03	...	0.74	...	2.47	2.77	...	...
...	1.20	2.79	2.63	0.34	1.72	1.68	0.24	...	...
...	...	...	...	...	...	1.41	17.51	...	...
...	...	...	...	...	...	2.80	23.11	...	...
1.89	2.06	...	3.09	3.95	2.73	5.65	1.89	...	...
3.08	3.67	0.21	1.94	0.94	2.19	8.28	9.50	...	...
...	...	...	...	...	...	5.73	11.28	...	...
...	...	...	...	...	...	...	...	...	...
0.40	2.64	0.08	3.36	1.92	2.73	5.90	6.57	...	...
...	...	...	...	4.41	...	...	...	...	...
0.13	0.15	...	...	6.01	...	...	...	...	...
...	0.19	...	...	0.57	...	...	...	...	...
...	...	...	...	13.72	...	...	...	...	...
...	...	...	...	14.85	...	...	...	...	...
...	...	...	...	8.28	...	...	...	...	...
...	0.15	...	...	1.46	...	...	...	...	...
...	...	...	...	...	...	1.18	24.77	...	...
10.89	12.66	...	...	...	...	...	...	...	...
...	2.52	...	...	4.46	...	...	...	...	...
...	...	...	...	9.27	...	...	...	...	...
...	...	...	...	7.54	...	...	...	...	...
...	...	...	...	6.87	...	...	...	...	...
...	...	...	...	7.22	...	...	...	...	...
0.50	0.72	...	...	0.97	...	...	...	...	...
0.44	0.63	...	...	0.55	...	...	...	...	...
0.32	0.64	...	...	1.18	...	...	...	...	...
0.36	0.56	...	...	0.88	...	...	...	...	...
0.58	0.98	...	...	0.76	...	...	...	...	...
0.44	0.78	...	...	0.78	...	...	...	...	...
...	...	...	...	0.69	...	...	...	...	...
...	...	...	...	...	...	...	...	54.09	...
...	...	...	0.59	...	...	...	...	38.54	...

Number of Analyses.	FERTILIZING MATERIAL.	Moisture.	NITROGEN.			PHOSPHORIC AC		
			Maximum.	Minimum.	Average.	Maximum.	Minimum.	
8	Lime, marble	....	....	....	....	....	....	0
1	" prec., carbonate of	....	....	....	....	....	....	....
4	" prec., phosphate of	....	....	....	....	33.27	22.39	28
9	" oyster shell	....	....	....	....	0.76	0.06	0
16	" prepared	....	....	....	....	0.63	0.26	0
2	" " and bone	....	0.60	0.12	0.36	8.20	2.20	5
10	" " and potash	....	....	....	....	0.67	0.26	0
1	" saltpeter	....	....	....	....	....	....	0
2	" sand	10.83	....	....	....	....	....	....
8	" slaked	....	....	....	....	0.49	0.23	0
1	Lime, soft-clam shell	....	....	....	....	....	....	0
13	" stone	....	....	....	....	0.73	0.36	0
1	" wonder	....	....	....	....	....	....	1
5	Limoid	....	....	....	....	0.55	0.31	0.
1	Linseed cake waste	....	....	....	6.78	....	....	1.
41	" meal	9.70	6.45	4.15	5.35	2.37	1.35	1.
1	Manure, Belgian hare	50.94	....	....	1.10	....	....	0.
17	" cow, solid fresh	84.69	0.46	0.29	0.36	0.43	0.17	0.
17	" " solid and liquid fresh	86.87	0.54	0.26	0.46	0.41	0.13	0
7	" " solid leached	79.59	0.60	0.36	0.45	0.50	0.26	0
7	" " solid and liquid leached	80.76	0.63	0.34	0.50	0.51	0.25	0.
1	Manure, duck	....	....	....	0.67	....	....	0.
3	" hen	57.60	1.23	0.73	1.04	1.12	0.46	0.
2	" horse	68.23	0.91	0.62	0.77	0.61	0.53	0.
4	" pigeon	57.66	4.87	1.34	2.94	2.67	0.82	1.
2	" sheep	....	2.96	1.87	2.42	2.27	0.76	1.
45	Marl	17.33	....	....	....	3.94	0.25	1.
1	" shell	....	....	....	....	....	....	0.
11	Muck	59.21	1.89	0.19	0.53	0.87	0.03	0.
3	" dried	....	1.45	0.25	0.98	0.56	0.40	0.
1	Mussels	68.19	....	....	0.90	....	....	0.
1	Oven sweepings (Spratt's)	....	....	....	5.15	....	....	2.
1	Peanut pulp	....	....	....	8.52	....	....	0.
1	Phosphate (Wolter's)	....	....	....	....	....	....	17.
1	Phosphoral	....	....	....	....	....	....	49.
1	Phosphorus works refuse	....	....	....	0.14	....	....	1.
1	Pigeon house rakings	....	....	....	3.09	....	....	1.
	Plaster, Cayuga	13.26	....	....	....	....	....	....

POTASH.			NITROGEN.			PHOSPHORIC ACID.				
Maximum.	Minimum.	Average.	Nitrates.	Ammonia.	Organic.	Soluble.	Reverted.	Insoluble.	Lime.	Magnesia.
									83.90	6.80
									51.20	
							26.87	2.01		
									65.12	
									52.23	20.34
					0.36				46.07	14.93
8.32	1.01	3.94							45.53	17.00
									80.64	
									23.04	1.16
									52.05	29.65
									50.52	
									50.53	34.55
		0.62					0.46	1.18	48.92	
									48.66	32.40
		0.66			6.78					
1.59	0.64	1.29			5.35					
		0.58							1.01	
0.29	0.12	0.20	0.01	0.03	0.32					
0.73	0.20	0.37	0.01	0.10	0.35					
0.35	0.14	0.22		0.03	0.42					
0.80	*0.17*	*0.38*		*0.09*	*0.41*					
		0.34			0.67					
0.45	0.36	0.42		0.34	0.70			0.15	2.51	
0.75	0.39	0.57								
1.66	0.43	1.14		0.71	2.23			0.20	2.78	
1.51	1.49	1.50								
0.86	*0.00*	*0.43*							*2.36*	
		0.06							30.00	
0.23	0.06	0.16			0.53				0.15	
0.29	0.07	0.20			0.98				0.56	
		0.13			0.90				15.84	
		0.48			5.15					
		1.21			*8.52*	*0.26*	*0.26*			
							12.18	5.18		
							4.61	44.79		
		0.28			0.14	0.63	0.34	0.30		
		1.31		0.46	2.63					
									20.61	

Number of Analyses.	FERTILIZING MATERIAL.	Moisture.	NITROGEN. Maximum.	NITROGEN. Minimum.	NITROGEN. Average.	PHOSPHORIC ACID. Maximum.	PHOSPHORIC ACID. Minimum.
11	Plaster, Nova Scotia	19.90					
2	" " " calcined						
2	" Onondaga	17.10					
1	Porpoise scrap				12.00		
9	Potash, bisulphate of						
19	" double sulphate of						
55	" high-grade sulphate of						
284	" muriate of						
2	" nitrate of		12.76	11.92	12.34		
1	" " " from tobacco extract				10.41		
1	Potash, phosphate of						
2	" prussiate of, waste					1.08	0.40
11	Poudrette		1.83	0.44	1.24	4.74	1.91
7	Prunings, apple		0.53	0.29	0.42	0.17	0.10
7	" cherry		0.51	0.28	0.35	0.16	0.10
1	" grape-vine	43.61			0.36		
9	" peach	45.80	0.78	0.38	0.53	0.23	0.08
14	" pear		0.56	0.36	0.44	0.27	0.16
16	" plum		0.56	0.23	0.41	0.23	0.10
7	" quince		0.49	0.31	0.41	0.23	0.09
1	Saltpeter waste				0.35		
1	Sea pumpkin	7.29			1.47		
1	Sewage, East Orange	57.18			0.52		
1	Slug, ground (horn pith)				4.79		
243	Soda, nitrate of		16.44	14.22	15.83		
2	Soot		0.48	0.18	0.33	0.78	0.20
1	Street sweepings				0.18		
1	Sturgeon, dried	5.52			4.45		
120	Superphosphate, bone-black					21.58	13.84
17	" double					45.82	31.68
7	" English					20.92	14.05
332	" S. C. rock					20.96	10.97
1	Sylvinit						
154	Tankage		9.12	2.95	6.01	22.34	2.31
2	" beef		4.34	3.35	3.85	19.97	10.11
2	" concentrated		11.28	11.13	11.21	3.46	0.63
7	" dissolved		6.96	2.07	4.29	13.60	7.02
4	" garbage	11.50	2.95	0.64	2.09	3.15	1.65

Potash.			Nitrogen.			Phosphoric Acid.				
Maximum.	Minimum.	Average.	Nitrates.	Ammonia.	Organic.	Soluble.	Reverted.	Insoluble.	Lime.	Magnesia.
									31.01	
									38.00	
									26.67	
					12.00					
36.93	30.05	34.17								
29.90	21.35	25.56								
53.47	42.73	49.53								
60.75	37.70	50.88								
45.24	43.96	44.60	12.34							
		40.78	9.94		0.47					
		49.96				49.96				
7.47	4.94	6.21								
1.87	0.16	0.46	0.06	0.24	0.94	0.47	2.37	0.50		
0.43	0.18	0.30			0.42					
0.32	0.12	0.22			0.35					
		0.37			0.36					
0.39	0.17	0.26			0.53					
0.40	0.15	0.28			0.44					
0.41	0.16	0.28			0.41					
0.52	0.27	0.40			0.41					
		1.02	0.35							
		0.37			1.47					
		0.10			0.52				11.06	
					4.79					
			15.83							
0.25	0.22	0.24			0.33					
		0.19			0.18					
					4.45					
						15.52	0.88	0.53		
						34.96	4.03	1.49		
						14.41	0.72	1.24		
						10.44	2.76	2.81		
		4.83								
					6.01					
					3.85					
					11.21					
					4.29	6.66	3.85	0.92		
1.36	0.61	0.91			2.09		1.34	0.88		

Number of Analyses.	FERTILIZING MATERIAL.	Moisture.	NITROGEN.			PHOSPHOR	
			Maximum.	Minimum.	Average.	Maximum.	Minimum.
4	Tankage, hog	....	7.00	4.90	6.02	18.91	10.
1	" refuse, (beef, milk and wheat)	....	....	....	5.18	....	......
3	Tannery refuse, hide coatings	....	12.98	4.35	7.59	....	......
1	" " lime and hair.	....	....	....	1.45	....	......
1	" " sediment	....	....	....	1.70	....	......
5	Texana manure	....	0.98	0.69	0.82	5.70	4.
4	Tobacco dust	....	2.53	1.03	1.50	0.56	0.
1	" leaf	....	....	....	3.18	....	......
7	" stems	....	2.89	1.70	2.37	1.11	0.
2	" and sulphur	....	2.42	2.35	2.39	0.91	0.
1	Tomato pomace	....	....	....	0.42	....	......
46	Tops, asparagus	62.32	1.06	0.29	0.56	0.22	0.
4	Vines, bean	78.33	0.72	0.59	0.66	0.19	0.
7	" pea	69.56	1.00	0.39	0.67	0.31	0.
1	" sweet potato, red	17.20	....	....	1.69	....	......
1	Vines, sweet potato, yellow	13.10	....	....	2.46	....	......
6	" tomato	37.19	0.96	0.83	0.88	0.49	0.
1	Waste, household, animal	58.70	....	....	1.64	....	......
	" " vegetable	84.46	....	....	0.30	....	......
1	Wool combings	....	....	....	10.80	....	......
4	Woolen waste	....	7.96	6.66	7.36	0.44	0.
18	Wool waste	....	3.27	1.18	2.44	0.62	0.

POTASH.			NITROGEN.			PHOSPHORIC ACID.				
Maximum.	Minimum.	Average.	Nitrogen.	Ammonia.	Organic.	Soluble.	Reverted.	Insoluble.	Lime.	Magnesia.
......	......	......	......	......	6.02	......	......	......	......	......
......	......	0.19	......	1.39	3.79	......	......	......	......	......
......	......	0.23	......	......	7.59	......	......	......	......	......
......	......	0.16	......	......	1.45	......	......	......	......	......
......	......	0.06	......	......	1.70	......	......	......	......	......
1.00	0.56	0.76	0.31	......	0.51	0.67	1.65	2.59	......	......
2.20	1.01	1.37	0.20	......	1.30	......	......	......	......	......
......	......	1.70	1.45	......	1.73	......	......	......	......	......
9.76	4.91	6.68	0.69	......	1.68	......	......	......	......	......
7.86	6.78	7.32	0.82	......	1.57	......	......	......	......	*0.91
......	......	0.18	......	......	0.42	......	......	......	......	......
1.16	0.41	0.74	......	......	0.56	......	......	......	......	......
0.57	0.40	0.51	......	......	0.66	......	......	......	......	......
1.10	0.30	0.61	......	......	0.67	......	......	......	......	......
......	......	1.44	......	......	1.69	......	......	......	......	......
......	......	1.69	......	......	2.46	......	......	......	......	......
0.49	0.19	0.37	......	......	0.88	......	......	......	......	......
......	......	0.30	......	......	1.64	......	......	......	......	......
......	......	0.54	......	......	0.30	......	......	......	......	......
......	......	0.27	......	......	10.80	......	......	......	......	......
0.22	0.19	0.21	......	......	7.36	......	......	......	......	......
3.32	0.19	2.22	......	......	2.44	......	......	......	......	......

* Sulphur.

II. The Detection of Peat in Commercial Fertilizers.

BY JOHN PHILLIPS STREET.

Recently several manufacturing plants have been establish for the drying and pulverizing of peat, and it is claimed that is the intention to use it as a drier in mixed fertilizers, and as diluent of dried blood. While this use of peat may serve a v uable end in improving the mechanical condition of fertilizers, also offers a temptation to the manufacturer to depend upon at least in part, for his nitrogen supply. Recent analyses of 1 samples of New Jersey peat show a range of from 0.74 to 2. per cent. nitrogen, with an average of 1.75 per cent. The ine ness of peat nitrogen is well established, and the possibility of utilization in the compounding of commercial fertilizers is, the fore, a matter of considerable importance.

Von Feilitzen and Tollens[1] have shown that pentosans a quite generally present in peat. Fifteen samples analysed l them contained from 2.65 to 12.75 per cent. of pentosans, tho taken from the upper and less decomposed layers containing t highest percentages. These high percentages were as a rule a companied by relatively high percentages of nitrogen. The facts suggested to the writer the possibility of employing t phloroglucin method, as used for the determination of pentosa in cattle feeds, as a means of detecting the presence of peat commercial fertilizers.

Seven samples of peat, differing widely in nature and mechai cal condition, were analysed with the following results:

	Total Nitrogen. %	Pentosans. %
No. 1	0.91	2.32
" 2	1.21	1.57
" 3	2.05	2.91
" 4	2.14	8.74
No. 5	2.65	4.98
" 6	2.72	2.57
" 7	2.98	3.56

The pentosans ranged from 1.57 to 8.74 per cent., with a average of 3.81 per cent., a high percentage of nitrogen and pe tosans in general being associated together.

[1] Bev. der. deut. Chem. Gesell, 30,2571.

The only material commonly used as a source of organic nitrogen in fertilizers, which might supply a considerable quantity of pentosans, is cottonseed meal, and this material has a very limited use in fertilizers in the northern and eastern markets. Average samples of tankage and dried blood were tested for pentosans, and were found to contain 0.75 and 0.47 per cent., respectively; this was in all likelihood partially due to an accidental contamination in both cases. Besides the official method for pentosans is hardly applicable where such small quantities of furfurol are obtained; three grams of the tankage yielded only .0204 gm. of phloroglucid and the same amount of blood yielded .0106 gm. The pentosan determination apparently gave high results with these two fertilizers, and it is doubtful if either contains more than a trace.

Three mixtures were prepared as follows:

Mixture No. 1. One part each of nitrate of soda, dried blood and tankage, five parts of acid phosphate and two parts of muriate of potash. It contained 3.27 per cent. nitrogen (1.57 as nitrates), 9.42 phosphoric acid, 10.09 potash and 0.12 pentosans.

Mixture No. 2. One part each of nitrate of soda, dried blood, tankage, peat (No. 5), four parts of acid phosphate and two parts of muriate of potash. It contained 3.53 per cent. nitrogen (1.57 as nitrates), 7.98 phosphoric acid, 10.09 potash and 0.62 pentosans.

Mixture No. 3. One part each of nitrate of soda, dried blood and tankage, three parts of peat, two parts of acid phosphate and two parts of muriate of potash. It contained 4.06 per cent. nitrogen (1.57 as nitrates), 5.10 phosphoric acid, 10.09 potash and 1.62 pentosans.

These mixtures represented in composition high-grade fertilizers, the first containing no peat, the second 10 per cent., and the third 30 per cent. It is doubtful if as small a quantity of peat as 10 per cent. would be used in actual practice, but it was used here to test the delicacy of the methods.

Pentosans were determined in each of the mixtures by the phloroglucin method. No. 1 yielded a trace, No. 2, 0.52 per cent., and No. 3, 1.41 per cent.; figures slightly below theory, but showing very fair agreement when the difficulties of the method are

taken into consideration. It is seen, therefore, that a pentosa determination will indicate as small an addition as 10 per cen of peat. If cottonseed meal, or castor pomace were used to cor pound the fertilizer, the test for pentosans would not establis with any certainty the use of peat, for these materials both coı tain pentosans. However, these materials are used but little i the Northern States (excepting castor pomace in tobacco fertili ers), and it is believed that this simple test will in the great ma jority of mixed fertilizers indicate whether or not peat has bee used; it will likewise serve for the detection of peat in drie blood.

III. Inspection of Concentrated Feeds.

The results of the sixth inspection of the concentrated feedin stuffs sold in the State, under the law of March 15th, 1900, wer published in Bulletin 193.

Summary.

1. Of the 125 different brands of feed received, and whic should have been guaranteed, four failed to meet this require ment.

2. Of the 241 samples which were guaranteed, ninety wer deficient, seventy-one of these being low in protein.

3. Of the 103 samples which did not require a guarantee, al were pure products, but the wheat brans and feeding flours wer below normal quality.

4. No direct adulteration is reported, but there are a numbe of feeds on the market whose composition does not warrant th high guarantee they carry.

5. The purchaser of protein will rarely find any feed contain ing less than 15 per cent. of protein a desirable or an economica purchase, and in all cases a strict regard must be given to th amount of nutrients guaranteed and the prices asked for th same.

Miscellaneous Analyses.

The following tabulation contains the analyses of a number of lders, chiefly grown on the College Farm, and which are pub-hed as a matter of record. During the past year the Station s also made fifty-three analyses of sundry samples, partially in nnection with the work of the other departments, and partly an accommodation to individual farmers. These samples in-ıded milk, cream, vinegar, insecticides and the leaves, fruit, igs and roots of various fruit trees :

MISCELLANEOUS FODDER ANALYSES.

FODDER.	Water.	Ether Extract.	Crude Fiber.	Protein.	Ash.	Nitrogen—free Extract.	Nitrogen.	Phosphoric Acid.	Potash.
	%	%	%	%	%	%	%	%	%
Oats and Peas Straw	5.56	2.00	37.56	5.04	7.46	42.38	0.81	0.40	....
" " Hay	5.56	2.65	31.63	8.78	7.53	43.85	1.41	0.58	2.16
Hay	10.52	2.54	28.41	6.14	5.39	47.00	0.98	0.44	1.97
Crimson Clover Hay	11.10	2.19	25.42	15.30	7.60	38.39	2.45	0.53	1.88
Alfalfa Hay	6.46	2.88	22.87	19.26	8.31	40.22	3.08	0.72	2.40
" "	6.83	2.92	21.10	18.51	8.96	41.68	2.96	0.63	2.46
" "	6.25	1.90	30.59	13.63	9.29	38.34	2.18	....	....
" "	5.94	2.17	33.44	13.30	6.41	38.74	2.13	....	....
" "	6.28	2.34	27.67	16.57	9.95	37.19	2.65	0.76	....
Cow Pea Hay	7.32	2.59	28.24	13.96	11.36	36.53	2.23	0.88	3.96
Foul Meadow Hay	7.69	2.63	25.79	6.94	7.74	49.21	1.11	....	....
Corn Silage	74.96	1.30	4.94	1.92	1.03	15.85	0.31	0.11	0.30
" "	71.93	1.04	7.26	1.73	1.91	16.13	0.28	....	....
" "	71.12	1.16	5.09	2.23	1.32	19.08	0.36	0.17	0.20
Cow Pea Silage	83.30	1.28	3.93	2.76	1.96	6.77	0.44	0.15	0.46
Soy Bean Silage	74.91	1.47	6.11	4.46	4.06	8.99	0.71	0.16	0.75
Corn Stover	29.12	1.34	20.15	3.81	4.50	41.08	0.61	0.39	1.14
Barnyard Millet (with Nitrate)	81.38	0.48	5.78	1.75	1.72	8.89	0.28	0.12	0.53
" " (no Nitrate)	79.00	0.57	6.71	1.28	1.84	10.60	0.21	0.15	0.51
Soy Beans	81.45	0.65	5.35	3.31	1.87	7.37	0.53	0.15	0.58
Winter Wheat and Hairy Vetch	66.86	0.86	9.76	2.70	1.87	17.95	0.43	0.22	0.67
Kafir Corn and Cow Peas	82.88	0.65	6.21	1.96	2.07	6.23	0.31	0.14	0.47

MARKET PRICES OF COMMERCIAL FEEDS.

Kind of Feed.	Average for the Six Months Preceding—May 1, 1902.	May 1, 1903.	May 1, 1904.	May 1, 1905.	May 1 1906.
Cottonseed Meal	$30 79	$29 85	$29 87	$29 25	$29 7
Linseed Meal	35 50	32 27	30 71	32 44	33 8
Gluten Feeds	27 30	25 81	25 73	25 46	25 9
Hominy Meal	27 77	25 62	23 89	24 88	23 4
Maizeline Feed	26 75	26 50	24 91	26 00	25 2
Corn Bran, or Sugar Feed	21 15	20 17	21 73	22 13	20 5
Corn Meal	28 95	....	24 62	25 48	24 6
Corn and Oats (Provender)	29 69	28 57	23 83	25 48	26 8
Cob Meal	23 80	....	....	....	19 5
Friends' Oat Feed	....	....	17 00	17 33	15 0
Royal Oat Feed	19 50	16 57	16 60	16 08	14 7
Vim Oat Feed	20 58	15 60	16 00	17 00	15 71
Wheat Feed	25 75	22 26	23 18	24 59	21 47
Wheat Bran	25 95	22 12	22 64	24 31	20 61
Wheat Middlings	28 75	25 28	26 71	26 71	24 31
Feeding Flour	28 33	27 40	27 75	29 13	26 27
Rye Bran	23 00	....	....	22 00	19 00
Rye Middlings	25 00	24 25	....	26 00	22 00
Rye Feed	25 25	24 36	....	25 00	22 50
Buckwheat Middlings	22 00	20 40	22 50	21 12	20 87
Buckwheat Bran	20 00	18 67	18 05	21 43	17 00
Buckwheat Feed	....	15 00	16 00	....	15 00
Barley Feed	....	26 00	25 00	24 63	21 00
Dried Distillers' Grains	21 67	18 50	23 67	25 57	27 13
Malt Sprouts	21 37	18 69	19 19	21 08	20 22
Dried Brewers' Grains	22 73	20 06	21 21	22 72	22 04
Molasses Grains	....	20 50	20 71	20 88	20 93
Buffalo Creamery Feed	....	....	....	27 50	28 00
Boss Corn and Oat Feed	23 50	22 30	22 60	22 00	22 00
H. O. Dairy Feed	29 00	29 33	29 00	29 50	28 00
H. O. Horse Feed	29 99	30 00	29 33	29 17	27 40
Sucrene Dairy Feed	26 00	....	....	24 00	24 09
Holstein Sugar Feed	....	....	....	22 30	21 00
Monarch Chop Feed	26 00	25 00	23 00	23 67	22 00
Quaker Dairy Feed	24 56	20 44	22 78	23 67	22 00
Schumacher's Stock Feed	30 75	28 67	26 20	26 60	24 00
Victor Corn and Oat Feed	25 61	22 90	22 55	22 86	21 33
Protena Dairy Feed	....	....	....	23 45	25 00
Alfalfa Meal	....	....	....	....	26 00
Dried Sugar Beet Pulp	....	....	18 50	22 00	20 33

The Carbohydrates of Sugar Beet Pulp.

BY JOHN PHILLIPS STREET.

Feeding experiments were conducted at this Station in 1904[1] sting dried beet pulp in comparison with dried molasses beet ılp and the latter with hominy meal. It was found that the dition of eight pounds of dried molasses beet pulp and seven unds of hominy meal to similar rations fed to milch cows, ve in fifteen-day periods a net gain of 81.6 pounds of milk and 31 pounds of butter for the molasses beet pulp ration. The erage fat content of the milk from the molasses beet pulp tion was slightly higher than that from the hominy. In the periment comparing the dried beet pulp with beet pulp which beet molasses had been added, it was found that the sweetened pulp gave a somewhat higher yield of milk and tter and the milk was of quite as good quality. These two periments show indirectly a rather marked superiority for ied beet pulp over hominy meal. These results are rather rprising inasmuch as those carbohydrates hitherto classed as e more easily assimilable had been in great measure removed om the beet pulp during the process of manufacture, while on e other hand the carbohydrates of the hominy consisted very gely of easily digested starch. It is clear from these experi- nts that either our methods of feed analysis are misleading that certain of the carbohydrates, generally classed as inferior d difficult of digestion, are in this feed at least of superior ality, and of a high rate of digestibility.

The ordinary analysis of cattle feeds has generally been lim- d to determining the moisture, fat, protein, ash and crude er, the undetermined matter being vaguely termed "nitrogen- e extract." It is well understood by all food chemists, that ne of these determinations, with the possible exception of the ı, is scientifically accurate. In the moisture determination latile matters, other than water, are frequently given off in all quantities, and the difficulty of drying to a constant weight a common experience. The product of our ether extraction,

N. J. Exper. Sta., Report, 1904, pp. 366 396.

called "crude fat," may consist of such dissimilar materials true fats and oils, lecithin, chlorophyll, resins, esters, terpe and coloring matters. *Our protein is calculated from the ni gen determination by the use of the arbitrary factor, 6.* although it is well known that the proteids commonly occurri in our ordinary feeds include members whose nitrogen conte varies from 14 to 19 per cent., and accordingly require fact varying from 7.14 to 5.27. The crude fiber determination admittedly inaccurate, the fiber always being contaminated w varying amounts of pentosans, ash and proteids, and in cert cases the cellulose itself is partly decomposed by the acid a alkali solvents used in the determination. These inaccurac in the methods of analysis are, however, in themselves of mi importance from a feeding standpoint, except that the algebr sum of all these errors, by our present method of calculation difference, falls upon the "nitrogen-free extract." Not onl *the aggregate percentage conceded to "nitrogen-free extrac usually inexact, but is manifestly unscientific* to group togetl under one heading such dissimilar substances as sugars, star gums, pectin, bodies, pentosans, lignin and the various mod cations of the hemicelluloses and oxycelluloses, especially wh they constitute such a large part of the feed under examinati varying from 26 per cent. in cottonseed meal to 80 per cent. rice. It is true that during the past few years much work l been accomplished, both in this country and abroad, towa the separation and identification of certain of these carbohydr compounds. Satisfactory methods have been worked out for t various sugars, for starch, pentosans and galactan and at leas beginning has been made towards the separation of lignin, cel lose and their various modifications. The feeding experime cited above show that not only do investigations of this natu have a chemical interest, from the standpoint of the analyst, b even more a direct application of the principles of nutritic

In dried beet pulp we have a feed, from which much t greater part of the sugar has been removed during manufactu and yet it possesses a feeding value superior to hominy me which contains one per cent. more protein, nearly twenty tin as much fat, and even more nitrogen-free extract, the grea

the latter being easily digested starch. Clearly the -free extract of this feed must at least in part be made iterials which are quite as easily digested by the animal rch. A thorough analytical study of dried beet pulp sefore, been undertaken, particulary as regards the car-tes, and the results of the study are herewith presented.

Scheme of Analysis.

heme of analysis employed was based on that adopted ', Browne *et al.*,[1] which in turn was a modification of oposed by G. Dragendorff[2] and by H. B. Parsons.[3] In mination of sugars, starch and the hydrolytic products acid and alkali digestion the method of H. C. Sherman[4] art adopted. At certain stages of the analytical process odifications were made by the writer as the exigencies of demanded.

ulp was dried in hydrogen, and then successively treated roleum ether, sulphuric ether, absolute alcohol, 80 per ohol, cold water, warm water, malt extract, dilute sul-cid, dilute sodium hydrate, and the residue chlorinated. act in each case was analysed as completely as possible, various residues examined for ash, nitrogen and pento-

lerable difficulty was experienced during the carrying is method of procedure by variations in hygroscopic . It was necessary to redry the substance after each ex-and in the effort to remove the final traces of moisture er of changing the composition of the material by pro-eating or over-heating was always present. As far as this danger was obviated by drying at a low tempera-ler 70°, or by partial drying over sulphuric acid with a al drying at 100°. Certain discrepancies of minor im-

'enna. State College, 1903–04, pp. 42 et seq.
alitative und quantitative Analyse von Pflanzen und Pflanzentheilen, 1882.
Chem. Jour., 1, pp. 377–391.
mer. Chem. Soc., 19, 291.

portance between the theoretical and actual amounts removed some of the extractives, as shown later by the analytical d are doubtless attributable to this cause.

Preliminary Analysis.

The finely-pulverized sample was analysed by the regu official methods with the following results:

Moisture.—2 gms. dried for five hours in hydrogen at 1(lost 0.2166 gm., or 10.83 per cent. Four portions of 4 g each dried for five hours in air at 100° lost 0.3983, 0.40 0.4107 and 0.4007 gm.; two hours longer drying caused furt losses of 0.0015, 0.0000, 0.0004 and 0.0013 gm., respective showing that five hours' drying was sufficient. The total los were 0.3998, 0.4035, 0.4111 and 0.4020, or 10.00, 10.09, 10. and 10.05 per cent., average (omitting third result), 10.05 p cent. This is 0.78 per cent. lower than when dried in hydrog showing that oxidation probably took place.

Ether Extract.—The residue from the hydrogen-dried samp extracted for twenty-seven hours with anhydrous sulphuric eth lost 0.0211 gm., or 1.06 per cent. The residues from the a dried samples, extracted for sixteen hours, with the same solve lost 0.0399, 0.0405 and 0.0415, or 1.00, 1.01 and 1.04 per cen average, 1.02 per cent.; whether the samples were dried hydrogen or air seemed to have little effect upon the ether extra

Crude Fiber.—The residue from the ether extract (hydroge dried) gave 0.3352 gm., or 16.76 per cent. fiber.

Protein.—The sample contained 1.261 per cent. total nitroge or 7.88 per cent. protein, and 1.201 per cent. albuminoid nitr gen, or 7.51 per cent. true albuminoid.

Pentosans.—3 gms. of the sample were distilled with 12 pe cent. hydrochloric acid, 270 cc. distillate collected, precipitate with phloroglucin free from diresorcin, made up to 500 cc. wit acid of the same strength, and allowed to stand for sixtee hours. 0.7272 gm. of phloroglucid was obtained, equivalent t 0.3794 gm. furfurol, or 21.54 per cent. pentosan, or 23.52 pe cent. araban, using Kröber's factors.[1]

[1] Jour. für Landw., 48, p. 375.

Galactan.—3 gms. of the sample were tested for galactan by he usual method (U. S. Department of Agriculture, Div. of 'hem., Bull. 46, 26), and 0.2080 gm. mucic acid was obtained, qual to 9.22 per cent. galactose, or 8.30 per cent. galactan.

Ash.—1 gm. of the sample ashed in the usual way gave a esidue of 0.0448 gm., or 4.48 per cent.

Nitrogen-free Extract.—The sum of the percentages of mois- ure, ether extract, crude fiber, protein and ash subtracted from 00, gave 58.99 per cent. in the sample dried in hydrogen, and 9.81 per cent. in the sample dried in air, this difference being lmost entirely due to the variation in the moisture determina- ion by the two methods.

The following is a summary of the analysis of the dried pulp y the official methods:

Analysis of the Pulp by Official Methods.

	Per cent.	Per cent.
Moisture, drying in hydrogen	10.83	....
" " " air	....	10.05
Ether extract, from hydrogen-dried sample	1.06	....
" " " air-dried "	....	1.02
Crude fiber	16.76	16.76
Protein (Albuminoids 7.51)	7.88	7.88
Pentosans, as araban	(23.52)	(23.52)
Galactan	(8.30)	(8.30)
Ash	4.48	4.48
Nitrogen-free extract	58.99	59.81
	100.00	100.00

Effect of Various Solvents.

Fifty grams of the air-dried beet pulp were subjected to the ction of the solvents already noted, and a summary of the re- ults follows, the analytical details of which will be given later. n the treatment with warm water and malt extract only a por- ion of the cold-water residue was used, the greater part being eserved for treatment with the dilute sulphuric acid. In the ollowing summary it is assumed, therefore, that the substances emoved by the warm water and diastase are included in the otal sulphuric acid extract, an assumption which may not be ntirely correct.

Materials Removed by Different Treatments.

	Per cent
Drying at 100°	9.86
Removed by petroleum ether	0.78
" " sulphuric ether	1.05
" " absolute alcohol	0 80
" " 80 per cent. alcohol	8.75
" " cold water	8.65
" " warm water	(7.02)
" " diastase (from warm water residue)	(3.88)
" " sulphuric acid (from cold water residue)	40.05
" " sodium hydrate	11.99
" " chlorination	6.21
Residue after chlorination (including 0.98 ash)	12.30
	100.44

The most striking fact brought out by the above summar the large amount of material removed by the dilute acid, 40 cent. of the original substance. As will be shown later, on small portion of this was starch, the greater part consisting easily-hydrolysed hemicelluloses. The residue after chlorinati which represents true cellulose, after deduction of the ash, sh 11.32 as compared with 16.76 by the official method. T difference is mainly due to pentosans and lignins, and reaffi the fact, already proven many times, that the residue obtai by the official method by no means consists of pure cellulose.

Analysis of the Residues.

After treatment with the different solvents, the residues in e case were examined for dry matter, total nitrogen, ash and pen sans, with the exception of the two ether residues, in which dry matter only was determined. Galactan was determined the 80 per cent. alcohol and cold water residues. As was to expected, certain discrepancies appear between the determi tions in the extracts and in the residues, but this was not s prising for, as has already been stated, the residues were su jected to a series of dryings, always attended by the danger changes in composition, and the frequent manipulation of t residues made mechanical losses almost unavoidable in certa cases. The 80 per cent. alcohol and cold water residues we particularly difficult to handle because of their sticky nature, a losses of 0.65 and 1.77 per cent., respectively, of the origin material were observed; likewise the sulphuric acid resid

showed a much smaller loss of dry matter than indicated by the analysis of the extract. These losses, however, have been considered in the calculations and due allowance made for them, and they in no way affect the conclusions drawn from the analysis, and merely give evidence of one of the many difficulties which confront the analyst in investigations of this nature.

The following tabulation shows the dry matter, nitrogen, ash and pentosans (calculated as araban) found in the various residues and extracts and the variations in the amount lost and the amount recovered.

Analysis of Residues.

	Dry Matter. %	Nitrogen. %	Ash. %	Araban. %
Original sample	90.49[1]	1.261	4.48	23.52
Petroleum ether residue A	89.71	......	......	......
Loss	0.78	......	......	......
Determined in extract A	0.79	......	......	......
Sulphuric ether residue B	88.66	......	......	......
Loss	1 05	......	......	......
Determined in extract B	1.05	......	......	......
Absolute alcohol residue C	87.86	1.231	4.39	23.21
Loss	0.80	0.030	0.09	0.31
Determined in extract C	0.80	0.000	0.08	......
80 per cent. alcohol residue D	78.48	1.173	3.87	23.39
Loss	9.40[2]	0.058	0.52	+0.18
Determined in extract D	8.75	0.122	0.34	......
Cold water residue E	68.06	1.157	2.54	18.55
Loss	10.42[3]	0.016	1.33	4.84
Determined in extract E	8.65	0.027	1.26	2.44
Warm water residue F	......	......	......	17.97
Loss	......	......	......	0.58
Determined in extract F	......	......	......	3.69
Diastase residue G	......	......	......	15.07
Loss	......	......	......	2.90
Determined in extract G	......	......	......	2.60
Sulphuric acid residue H	30.50	0.712	1.18	2.10
Loss	37.56	0.445	1.36	16.45
Determined in Extract H	40.05	0.418	*1.36	11.50
Sodium hydrate residue I	18.51	0.018	0.98	1.05
Loss	11.99	0.694	0.20	1.05
Determined in extract I	11.99	*0.694	*0.20	0.47
Chlorination residue J	12.02	0.000	0.98	Trace.
Loss	6.49	0.018	0.00	1.05
Determined in extract	*6.49	*0.018	*0.00	*1.05

* Calculated from residue.
[1] 0.35 per cent. increase due to oxidation.
[2] 0.65 per cent. loss in transferring.
[3] 1.77 per cent. loss in transferring.

The only serious discrepancies shown in the table are in t araban determinations, in which there are wide variations, p ticularly in the water and sulphuric acid residues; these will discussed on a later page. From the above results it appe that the bulk of the proteids and ash are removed during acid and alkali digestions, although nearly one-fourth of original ash still remains in the chlorinated residue. The aral is practically unaffected by the ether and alcohol extractic but large quantities are removed by cold water and sulphu acid, especially the latter; the chlorinated residue contained or an incalculable trace.

Examination of the Extracts.

50 gms. of the material were weighed into twelve extract thimbles, and dried in a water bath at 100° for five hou There was a loss of 4.9305 gms., equal to 9.86 per cent. origir One and one-half hours' longer heating gave an increase in wei of 0.1732 gm., or 0.35 per cent., doubtless due to oxidation.

Petroleum Ether Extract.

The residues from the moisture determinations were extrac with petroleum ether. The boiling point of the ether was high, 65°–70°, that volatilization was extremely difficult in regular fat apparatus. As the expected amount of extract w so small, and as this particular extraction was only incidental the general scheme and purpose of the analysis, three separ siphonings of the ether were taken, fresh ether being added ea time. Admittedly this was an imperfect extraction, but matters readily attacked by this solvent should be obtained this way, the remaining ether-soluble materials being remov by the sulphuric ether extraction. The siphonings from t samples were collected in a 1000 cc. flask, and the flask filled the mark with petroleum ether (extract A). The extract w nearly colorless. Two 50 cc. portions were pipetted into platinu dishes, and evaporated almost to dryness under reduced pressu and the drying completed in a water oven. The extract weigh 0.0396 gm., or 0.792 per cent. The residue from the petroleu

her extraction was dried at from 70°–80° in a water oven for o and one-half hours, and showed a loss of 0.3893 gm., or 779 per cent., practically identical with the determined weight the extract.

Sulphuric Ether Extract.

The residue from the last extraction, 44.8534 gms., was exacted for eighteen hours with anhydrous sulphuric ether, and e extract made up to 500 cc. with ether (extract B). It was of light yellow color. Two 50 cc. portions of the extract were aporated at room temperature and finally dried in a water en, each portion giving a residue of 0.0161 gm., or 0.322 per nt. original. These results, however, were deemed untrustorthy as during the evaporation the ether crept over the edges the dishes and an undoubted loss occurred. The residue om this extraction was dried for four hours in a water oven, nder 70°, and showed a loss of 0.5241 gm., or 1.05 per cent. iginal. This result agrees very closely with those obtained by e official method, without previous extraction with petroleum her, namely, 1.06 and 1.02 per cent.

Absolute Alcohol Extract.

The residue from the sulphuric ether extraction, 44.3293 gms., as transferred to a large beaker and digested with absolute cohol for seventy hours with frequent stirring. The extract as decanted from time to time on a Hirsch funnel, covered with disk of hardened filter paper and the total extract made up to 00 cc. with absolute alcohol (extract C). It was of a yellowish lor. The residue was dried in a water oven, from 70°–85°, for x hours, and showed a loss of 0.3993 gm., or 0.799 per cent. iginal. 50 cc. of the extract, evaporated and dried, gave a sidue of 0.0205 gm., or 0.820 per cent. This residue was ashed the usual way and gave 0.084 per cent. ash. 50 cc., equal to 5 gms. original, were used for a determination of total nitrogen nd gave a negative result.

100 cc. of extract, equal to 5 gms. original, were heated ntil all the alcohol had been driven off, a little water being

added towards the end to prevent the separation of wat soluble matters; only a very small insoluble residue remaine 0.0028 gm., or 0.056 per cent. original. The water-soluble e tract was made up to 100 cc. with water and 20 cc. precipitat with neutral lead acetate, the precipitate was washed and dri and on ignition lost 0.0052 gm., or 0.52 per cent. original. was flocculent and of a dirty-white color. 20 cc. of the sar extract were precipitated with basic lead acetate, and, on bei treated as above, lost on ignition 0.0072 gm., or 0.72 per cer original. This precipitate was whitish and rather granular texture. Aliquots were also used for estimating reducing suga and sucrose. Only a trace of reducing sugar was found and i sucrose.

Absolute Alcohol Extract.

	Total Extract. %	Original Material. %
Insoluble in water (colors, waxes, resins, etc.)....	7.00	0.056
Soluble in water..........	(93.00)	(0.743)
Copper-reducing substance, as dextrose......	0.00	0.000
" " " after inversion..	0.00	0.000
Precipitated by neutral lead acetate (organic acids)........	65.08	0.520
Additional precipitate by basic lead acetate (acids)........	25.02	0.200
Undetermined extractives........	2.90	0.023
		0.799
Ash........	10.51	0.084
Total nitrogen........	0.00	0.000

Eighty Per Cent. Alcohol Extract.

8.7800 gms. of the absolute alcohol residue were reserved f analysis; the balance, 35.1500 gms., equivalent to 40 gm original, was digested in a large beaker with 80 per cen alcohol. 100 cc. portions of the solvent were added three time and the material allowed to digest therein for seventeen, eig and seventeen hours, respectively, forty-two hours in all, wit frequent stirring. The material was then transferred to a larg filter and washed with 80 per cent. alcohol, 15 cc. at a tim

ntil the extract amounted to 1000 cc., (extract D), the extract t that time showing no color; the total extract was of a yel-)wish-brown color, showing the presence of chlorophyll, or ther extractives, even after prolonged treatment with ether and bsolute alcohol. On long standing a brownish material sepa- ated out from the alcoholic extract, but it was so finely divided hat it was possible to distribute it uniformly through the mix- ure and in the various aliquots taken for analysis. Frear[1] and is associates found a similar material in the alcoholic extract 'om timothy hay.

Two 25 cc. portions of the extract, evaporated and dried, gave esidues of 0.0876 and 0.0873 gm., or 8.75 per cent. original. 'he residue from the 80 per cent. alcohol extraction was dried or twelve hours at room temperature, then dried to constant 'eight in a water oven, at a low temperature. It showed a loss of .7590 gms., or 9.40 per cent. original. There was an unavoid- ble loss of material as it was impossible to remove it entirely 'om the filter; this loss amounted to 0.65 per cent., 7.8478 gms. f the residue were reserved for analysis.

The extract contained 0.35 per cent. ash and 0.122 per cent. otal nitrogen.

100 cc. of the extract were freed of alcohol on a water bath at 0°–85°, and were then transferred to a filter, washed with hot 'ater and the filtrate made up to 200 cc. The extract insoluble ı water amounted to 0.0112 gms., or 0.28 per cent. original; .47 per cent. of the extract was therefore soluble in water.

25 cc. of the water-soluble extract were precipitated with mmonical zinc acetate. The precipitate was dried, weighed, gnited and again weighed, and showed a loss during ignition f 0.0012 gm., or 0.12 per cent. original, supposedly tannin.

25 cc. of the water-soluble extract were likewise precipitated ith neutral lead acetate, and gave a loss on ignition of 0.0140 ms., or 1.40 per cent. original.

25 cc. of the water-soluble extract were also precipitated with asic lead acetate and showed on ignition a loss of 3.46 per cent. riginal.

[1] Rept. Penna. State College, 1903–04, p. 66.

Another 100 cc. portion of the alcohol extract was evaporat as before, taken up with water, filtered and washed, and t water-soluble filtrate made up to 200 cc. 50 cc. were precipitat with basic lead acetate, the excess of lead removed, with sodiu carbonate, filtered, washed and made up to 250 cc. Reducir sugars were determined by Fehling's solution in a 50 cc. portic (equal 0.20 gm.) and 0.0050 gms. copper oxid, equivalent 1.21 per cent. dextrose was obtained.

Another 50 cc. portion of the original extract was precipitate with basic lead acetate, and after removal of excess of lead treate with 5 cc. of strong hydrochloric acid for thirty minutes at 68 On cooling it was neutralized with sodium carbonate and made u to 100 cc. 50 cc. of this solution treated with Fehling's solutic gave 0.0575 gms. of copper oxid, equivalent to 5.29 per cen dextrose. Deducting the reducing sugars found before inve sion, 1.21 per cent., we have 4.08 per cent., which multiplied b 0.95 gives 3.88 per cent. sucrose.

On examining the 80 per cent. alcohol residue for galacta 5.63 per cent., equal to 6.26 per cent. galactose was found, ind cating that 2.67 per cent. galactan, or 2.96 per cent. galactos had been removed by the alcohol. The presence of dextros invert sugar and galactose indicates that at least a part of thes compounds found in the alcoholic extract should be attribute to raffinose, a normal constituent of sugar beets. It is impo sible to say how much of the dextrose and invert sugar belong to raffinose, and how much to other sources, but it is very prol able that the greater part of the reducing and invert sugars, a well as part of the matter precipitated by lead acetate, hav raffinose as their source.

The sum of the various determinations in the water-solubl extract slightly exceeds the total, doubtless due to experimenta errors.

Eighty Per Cent. Alcohol Extract.

	Total Extract. %	Original Material. %
soluble in water	3.20	0.28
ater-soluble extract	(96.80)	(8.47)
Matters prec by ammoniacal zinc acetate	1.37	0.12
*Additional matters prec. by neutral lead acetate	14.63	1.28
* " " " " basic lead acetate	23.54	2.06
* Reducing sugars, as dextrose	13.83	1.21
* Invert sugar, as sucrose	44.34	3.88
	100.91	(8.83)
Total extract determined direct		8.75
h	3.94	0.345
tal nitrogen	1.39	0.122
lactan (=2 96 % galactose)	....	2.67

Cold Water Extract.

23.5432 gms. of the 80 per cent. alcohol residue were transrred to a 500 cc. beaker and 150 cc. of water added, slightly ipregnated with thymol to prevent fermentation. This was lowed to stand with frequent maceration for forty-three hours; e residue was then transferred to a large filter, and washed th water, 15 cc. at a time, until the extract amounted to 1,000 . (extract E); the extract was grayish-yellow in color.

Two 50 cc. portions of the extract were dried in a water-oven id showed residues of 0.1297 and 0.1298 gm., or 8.65 per cent. iginal; the residue was transparent and gelatin-like in appearce. The total residue from this extraction was dried to conint weight in the water-oven, and showed a loss of 3.1259 gms., 10.42 per cent. original; this figure is 1.77 per cent. higher an that obtained from evaporating the extract, and the differce is undoubtedly very largely due to losses in transferring e sticky residue from the filter paper. 10.1474 gms. of this sidue were reserved for analysis.

The residues of the water-extract were ashed, and showed)187 and 0.0192 gm., or 1.26 per cent. ash in the original. ie extract contained 0.027 per cent. total nitrogen.

* Probably very largely a component part of raffinose.

200 cc. of the water-extract, equal to 6 gms. of the original material were evaporated to about 20 cc. and a large excess of strong alcohol (92 per cent.) added. A bulky, whitish, gelatinous precipitate settled out. This was filtered through a Gooch crucible, washed with strong alcohol, and dried at 90°–95°. The filtration was exceedingly difficult, several days being necessary. The dried residue weighed 0.3485 gm., 0.0542 gm. of which by a separate determination was found to be ash; the ash-free alcohol precipitate, therefore, weighed 0.2943 gm., or 4.91 per cent. original.

0.1000 gm. of this precipitate, equal to 1.72 gms. original, was transferred to a 50 cc. flask, dissolved in water and reducing sugars determined. 25 cc. or 0.86 gms. original, reduced 0.0088 gm. copper oxid, equal to 0.44 per cent. dextrose.

0.1750 gm. of the same precipitate, equal to 3.01 gms. original, was used for the determination of pentosans in the usual way. It yielded 0.0514 gm. phloroglucid, equal to 1.84 per cent. araban, using Kröber's factors.

The filtrate from the alcohol precipitate was made up to 100 cc. with strong alcohol. 25 cc. of this solution, equal to 1.5 gms. original, were pipetted into a beaker, freed of alcohol and precipitated with basic lead acetate; ash was also determined in a separate 25 cc. portion, giving 0.0054 gm., or 0.36 per cent. original. The lead precipitate after drying and ignition showed a loss of 0.0266 gm., or 1.77 per cent. original, the amount of organic matter soluble in strong alcohol.

50 cc. of the water-soluble extract were precipitated with basic lead acetate, dried and ignited, and showed a loss on ignition of 0.0906 gm., or 6.04 per cent. original. Another 50 cc. portion of the water-extract was precipitated with neutral lead acetate, dried and ignited as before, and showed a loss of 0.0582 gm., or 3.88 per cent. original. The filtrate from the neutral acetate precipitation was treated with additional neutral acetate, boiled and filtered and washed. After drying this precipitate lost 0.0135 gm. on ignition, or 0.90 per cent. original; this according to Allen[1] is parapectin.

[1] Commercial Organic Analysis, 1, p. 350.

25 cc. of the water-extract were pipetted into a 500 cc. flask, 30 cc. strong hydrochloric acid and 45 cc. water added, thus making 100 cc. of 12 per cent. hydrochloric acid, and the furfurol distilled off. A precipitate of 0.0137 gm. phloroglucid was obtained, equal to 2.44 per cent. araban.

The residue from the cold-water extraction contained 3.40 per cent. galactan, equal to 3.78 per cent. galactose, showing a loss due to the extraction of 2.23 per cent. galactan, or 2.48 per cent. galactose. Reiss claims[1] that raffinose and galactose are precipitated from alcoholic solutions, the other sugars from alkaline watery solutions, by lead acetate. The organic matter precipitated by lead acetate is therefore classed as galactose, and the underdetermined alcohol-soluble matter may also possibly be due to this sugar.

From the above data, it is possible to determine approximately the composition of the water extract. The alcohol precipitate would probably consist of araban, parapectin and pectin; by difference, therefore, the pectin amounts to 2.17 per cent. As there was 2.44 per cent. of araban in the total extract, and but 1.84 per cent. in the alcohol precipitate, the difference, 0.60 per cent., must be credited to the lead acetate precipitate in the alcoholic filtrate; the balance of this precipitate as stated above is probably galactose. It is admitted that some of these deductions are not based on well authenticated data, but it is believed that they are approximately correct, except possibly in the case of pectin, a part of which may be due to organic acids insoluble in alcohol. Furthermore, the per cent. of araban found in the alcoholic filtrate is open to question, as the amounts of material used for the pentosan determination were necessarily small, and a very small error in analysis would be greatly magnified in the calculation. The percentage thus attributed to araban may be galactose, which seems all the more probable, as the total amount of material soluble in alcohol, 2.48 per cent., is exactly equal to the amount of galactose removed by the cold water extraction; this, however, may simply be a coincidence.

[1] Landw. Jahres. 18, 753.

Cold Water Extract.

	Total Extract. %	Original Material. %
Ash	(14.57)	(1.26)
Insoluble in alcohol	10.40	0.90
Soluble in alcohol	4.17	0.36
Total organic extract	(85.43)	(7.39)
Alcohol precipitate (ash-free)	(56.76)	(4.91)
Araban	21.27	1.84
Pectin (probably also organic acids)	25.09	2.17
Parapectin	10.40	0.90
Soluble in alcohol (ash-free)	(28.67)	(2 48)
Precipitated by basic lead acetate	(20.46)	(1.77)
Araban (?)	6.94	0.60
Galactose	13.52	1.17
Undetermined (galactose (?)).	8.21	0.71
	100.00	8.65
Total nitrogen	0.31	0.027
Galactan (= 2.48 % galactose)	......	2.23

Warm Water Extract.

Three gms. of the cold water residue, equal to 4.4079 gms. original material, were heated with 100 cc. of water for four hours, at 45 to 50°, filtered and washed with water, and made up to 200 cc. This extract gave no blue or red color on addition of iodin. On adding 100 cc. of 92 per cent. alcohol to 25 cc. of the extract, a flocculent white precipitate was formed, which on drying and igniting lost 0.0258 gm. or 4.68 per cent. original.

25 cc. of the extract were evaporated and dried, giving a residue of 0.0387 gm., or 7.02 per cent. original material. This was ashed and 0.0063 gm., or 1.14 per cent. of ash in the original material was found.

50 cc. of the extract were treated for three hours with dilute hydrochloric acid at a temperature under 70°, then strong hydrochloric acid was added and the solution heated with reflux condenser in a boiling water bath, for two and one-half hours. The liquid was then neutralized with sodium hydrate and a whitish, gelatinous precipitate separated, which was not weighed.

The liquid was then filtered, made up to 500 cc. and 25 cc. of the filtrate treated with Fehling's solution in the usual way. *On ignition 0.0036 gm. of copper oxid was obtained.* This is equivalent to the reducing power of .00145 gm. dextrose or 2.63 per cent. of dextrose in the original substance. It appears, therefore, that the warm water treatment has removed a substance, which, under the same treatment as the malt extract is finally subjected to, produces a reducing effect equivalent to that of 2.63 per cent. of dextrose, or 2.37 per cent. of starch, in the original material.

50 cc. of the extract was made up to 100 cc., with strong hydrochloric acid and water, so that the solution contained 12 per cent. of hydrochloric acid, and pentosans determined: 0.0365 gm. phloroglucid was obtained, equal to 3.69 per cent. araban. The greater part of the reducing power above referred to was doubtless due to the araban present. These results indicate either that the araban exists in this material in forms possessing different properties, or that the furfurol-yielding bodies are complexes of varying resistance to cold and warm water. 4.68 per cent. of this extract was precipitated by alcohol, while the reducing *power was equivalent to but 2.63 per cent. dextrose, and the* furfurol obtained corresponded to but 3.69 per cent. araban. The alcohol precipitate included other gum or gums than araban, of apparently low reducing power; these, however, with the material in hand could not be identified.

Diastase Extract.

2.1555 gms. of the warm water residue, equal to 3.5 gms. of the original material, were treated with malt extract in the usual manner for starch determination. The diastase residue after drying weighed 2.0198 gms., showing a loss of 0.1357 gm., or 3.88 per cent., due to the action of the diastase. On treating 25 cc. of the filtered diastase extract with Fehling's solution, 0.0530 gm. copper oxid was obtained; the blank determination for the malt extract gave 0.0344 gm. of copper oxid, so that 0.0186 gm. of copper oxid was reduced by the solution, equiva-

lent to 0.0072 gm., or 5.05 per cent. of starch in the original material. This result is obviously wrong, being 1.17 per cent. more than the total extract. The balance of the diastase extract having been thrown away, it was necessary to revert to the original material for a new determination of starch. 3 gms. of the material were extracted with ether, 10 per cent. alcohol, and strong alcohol according to the regular method. The residue after gelatinization was treated with 25 cc. of malt extract at 55° until the residue revealed no starch under the microscope. The solution was made up to 250 cc., filtered, and 200 cc. treated with 20 cc. of 25 per cent. hydrochloric acid under a reflux condenser in a boiling water bath for two and one-half hours; the solution was nearly neutralized, while hot, with sodium carbonate, and made up to 500 cc., and filtered. 50 cc. portions were treated with Fehling's solution, and gave 0.0637 and 0.0644 gm. of copper oxid. The blank determined in the malt extract gave 0.0510 gm. copper oxid, which deducted from the above weights gave 0.0127 and 0.0134 gm. copper oxid, equivalent to 2.82 and 2.94 per cent. dextrose, or 2.54 and 2.65 per cent. starch.

50 cc. of the original diastase extract were distilled with 12 per cent. hydrochloric acid and the pentosans determined. These yielded 0.0046 gm. phloroglucid. 50 cc. of the malt extract examined for pentosans in the same way gave 0.0459 gm. phloroglucid. As 50 cc. of the diastase extract contained 2.4 cc. of the malt extract, a correction of 0.0022 gm. phloroglucid is necessary in the pentosan determination, so that we have 0.0024 gm. phloroglucid, equivalent to 2.60 per cent. araban. It is evident, therefore, that a part of the pentosans are soluble in malt extract, and that the percentage of 2.88 dextrose, obtained after inversion in the diastase extract, was not due to starch present. Using Stone's formula[1] (dextrose X .97 X .88 = pentosans), it is seen that the 2.88 per cent. dextrose obtained is equal to 2.46 per cent. pentosans, or 2.68 per cent. araban, a figure practically identical with the result obtained for araban in the diastase extract.

[1] Amer. Chem. Jour., 13, p. 73.

Sulphuric Acid Extract.

10.2699 gms. of the cold-water residue, equal to 15.09 gms. of original material, were divided into five portions of approximately two grams each and digested for thirty minutes with 200 cc. boiling 1.25 per cent. sulphuric acid, filtered on a Hirsch funnel, washed with hot water and made up to 2000 cc. with water; the extract was light yellow in color. 50 cc. of the extract were neutralized with 9/100 N. sodium hydrate, using phenolphthalein as an indicator, 71.35 cc. of the alkaline solution being required. The solution was then evaporated and complete dryness obtained by heating in a water oven at 100°. The residue weighed 0.6070 gm., of which 0.4559 gm. represents the sodium sulphate formed by the above treatment. The difference, 0.1511 gm., is, therefore, due to the extract itself, and is equivalent to 40.05 per cent. of the original substance. By drying the sulphuric-acid residue, a loss of 5.6681 gms., or 37.56 per cent., was shown, but it is believed that the determination made from the extract itself is the more trustworthy. The ash in the extract, owing to the large amount of sodium salts present, was determined by difference from the ash of the cold-water and sulphuric-acid residue. This was found to be 1.36 per cent. of the original material. Total nitrogen was determined in 50 cc. of the extract, giving a percentage of 0.418 in the original material.

100 cc. of the extract were neutralized with sodium carbonate, filtered and made up to 200 cc. 50 cc. were pipetted off and Fehling's solution added in the usual way; 0.0698 gm. of copper oxid was obtained, equivalent to 16.86 per cent. dextrose in the original material. Another 50 cc. portion was neutralized with sodium carbonate, 20 cc. strong hydrochloric acid added and the solution heated in a water bath under 70° C. for three hours. The solution was then again neutralized with sodium carbonate, filtered and made up to 100 cc. 50 cc. of this solution were treated with Fehling's solution as before, and yielded 0.0842 gm. copper oxid, equivalent to 20.25 per cent. dextrose in the original substance. This increase of 3.39 per cent. after inversion indi-

cates that the dilute sulphuric acid dissolved materials in an incompletely hydrolysed state.

400 cc. of the extract, equal to 3.0180 gms. of original material, were concentrated to 100 cc., being previously neutralized with sodium carbonate. 43 cc. of hydrochloric acid were added to make the solution equivalent to a 12 per cent. solution of hydrochloric acid. 300 cc. were distilled off and precipitated with phloroglucin, giving 0.3534 gm. phloroglucid, equivalent to 10.55 per cent. pentosans, or 11.50 per cent. araban.

25 cc. of the extract were treated with a large excess of strong alcohol, without the formation of any precipitate. On neutralzing with ammonia, however, a light, flocculent precipitate appeared, which lost on ignition 0.0337 gm., or 17.87 per cent. original substance.

Galactan was not determined in the sulphuric acid extract, but it undoubtedly contained the balance of galactan not extracted by cold water, 3.40 per cent., or 3.78 per cent. galactose.

Sulphuric Acid Extract.

	Total Extract. %	Original Material. %
Total extract	(100.00)	(40.05)
Ash	(3.40)	(1.36)
Soluble in hot water	2.85	1.14
Insoluble in hot water	0.55	0.22
Total organic matter	(96.60)	(38.69)
Precipitated by 92 % alcohol	(44.62)	(17.87)
* Reducing sugar, as dextrose	(42.10)	(16.86)
* Invert sugar, as sucrose	8.04	3.22
Galactose (= 3.40 % galactan)	......	(3.78)
Araban, from furfurol distillation	(28.71)	(11.50)
" calculated from reducing sugars	(41.70)	(16.70)
" in warm water extract	9.20	3.69
" in diastase extract	6.48	2.60
" dissolved by acid, additional	26.02	10.41
Nitrogen	(1.04)	(0.418)
Protein (N x 6.25)	6.51	2.61
* Undetermined hemicelluloses	40.35	16.16
	100.00	40.05
Araban calculated from differences in cold water and acid residues	41.07	16.45

* Probably partially due to raffinose.

The above summary of the results secured from the examination of the warm water, diastase and acid extracts gives some interesting data. In the first place, 3.22 per cent. of invert sugar was obtained in the acid extract. 3.88 per cent. of invert sugar was found in the 80 per cent. alcohol extract, and none in the cold water extract, so that the invert sugar here found possesses the characteristic of being insoluble in both 80 per cent. alcohol and cold water. It has already been shown that 2.44 per cent. of araban was soluble in cold water; the tabulation shows, however, that other arabans of varying resistance to solvents are present, 16.70 per cent. being soluble in dilute sulphuric acid, and 3.69 per cent. of this soluble in warm water, and 2.60 per cent. in diastase extract. As will be seen later, another portion of the araban, 1.05 per cent., is further dissolved by dilute alkali. The arabans of the beet pulp, therefore, seem to exist as complexes, varying greatly in their resistance to solvents.

The most important point brought out by the examination of the acid extract is that 40.35 per cent. of the extract, or 16.16 per cent. of the original material, consists of undetermined hemicelluloses. A part of this is doubtless galactose, for, as already shown, the acid extract contained 3.78 per cent. galactose. If this galactose had its origin in raffinose, which is undoubtedly the case, a part of the reducing sugar, and probably all of the invert sugar as given in the above table, are also attributable to raffinose. However, even with this assumption, which seems based on well-established data, a very large part of the acid extract is still unaccounted for. As already pointed out, the carbohydrates which undergo hydrolysis should be as valuable from a feeding standpoint as starch, and it is important to determine accurately their nature and the frequency of their occurrence in our cattle feeds. Much further study will be necessary for a clear solution of this problem, and these results are presented merely as being suggestive rather than conclusive.

Sodium Hydrate Extract.

3.1018 gms. of the residue from the sulphuric acid extraction, equal to 10.1714 gms. original substance, were treated with 200 cc. of boiling 1.25 per cent. sodium hydrate solution in two portions for thirty minutes, filtered, washed with hot water, and made up with water to 600 cc.; the extract was brownish in color. The residue weighed 1.8830 gms., showing a loss of 1.2188 gms., or 11.99 per cent., due to the action of the alkali. The ash was determined by difference from the ash of the acid and alkali residues, and was found to be 0.20 per cent. of original substance. The total nitrogen in the extract was found by difference to be 0.694 per cent.

50 cc. of the extract were neutralized with dilute sulphuric acid, and inverted in the usual manner, and dextrose determined as in the acid extract, but only a trace of dextrose was found.

200 cc. of the extract, equal to 3.3904 gms. original material, were neutralized with 12 per cent. sulphuric acid and concentrated to 100 cc. and 43 cc. strong hydrochloric acid added to make a 12 per cent. solution. 300 cc. of the distillate precipitated with phlotoglucin gave 0.0113 gm. phloroglucid, equal to 0.47 per cent. araban.

Sodium Hydrate Extract.

	Total Extract. %	Original Material. %
Total extract	(100.00)	(11.99)
Ash	1.67	0.20
Organic matter	(98.33)	(11.79)
Reducing sugars after inversion	......	Trace.
Protein (N x 6.25)	36.11	4.33
Araban	3.92	0.47
Lignin acids (by difference)	58.30	6.99
	100.00	11.99

Chlorination.

The balance of the alkali residue, 0.8835 gm., equal to 4.7724 gms. of original substance, was moistened with water and placed in a beaker, into which a slow stream of chlorin gas was passed for one hour. The residue was then washed twice with water to

remove hydrochloric acid, and placed in a 2 per cent. solution of sodium sulphite; the solution was gradually raised to the boiling point, a small quantity of sodium hydrate added (0.2 per cent. sodium hydrate in whole solution), and the boiling continued for five minutes. The residue was then transferred to a Gooch filter and washed with hot water. To remove the last traces of non-cellulose dilute permanganate of potash (0.1 per cent. solution) was added; the residue was washed thoroughly with water, treated with sulphurous acid on the filter, washed again with water, dried and weighed. The residue weighed 0.5869 gm., showing a loss due to chlorination of 0.2966 gm., or 6.21 per cent. lignin. The residue was dark in color, in fact darker than before the chlorination treatment, and it is difficult to explain the cause, unless there had been a reduction of the permanganate. Every precaution, however, was taken to remove this reagent prior to the sulphurous acid treatment, the filtrate at that time being perfectly colorless.

Nitrogen was not determined in this residue, as the residue from the alkali treatment had shown only a trace. The residue yielded 0.98 per cent. ash, and a mere trace of pentosans. The difference between the total residue and the ash may be considered to be cellulose, namely, 11.32 per cent.

Summary of Analyses of Extracts.

	Original Material. %
Water, loss at 100° in air	9.86
Petroleum ether extract	......
(Fats, waxes, resins, colors)	0.78[1]
Sulphuric ether extract	......
(Fats, waxes, resins, colors)	1.05[1]
Absolute alcohol extract	(0.80)
Insoluble in water (colors, waxes, resins, etc.)	0.06
Soluble in water	(0.74)
Prec. by neutral lead acetate (organic acids)	0.52
Add. prec. by lead subacetate (organic acids)	0.20
Ash	(0.08)
Undetermined extractives	0.02

[1] Combined extracts contained 0.03 per cent. nitrogen and 0.09 ash.

	Original Material.
	%
80 per cent. alcohol extract	(8.75)
Insoluble in water	0.28
Soluble in water	(8.47)
Precipitated by ammon. zinc acetate (tannin)	0.12
[1]Add. prec. by neutral lead acetate (organic acids)	1.28
[1]Add. prec. by lead subacetate (organic acids)	2.06
[1]Reducing sugars, as dextrose	1.21
[1]Invert sugars, as sucrose	3.88
Galactan	(2.67)
Ash	(0.35)
Nitrogen	(0.122)
Cold water extract	(8.65)
Ash	(1.26)
Insoluble in alcohol	0.90
Soluble in alcohol	0.36
Organic matter	(7.39)
Alcohol precipitate (ash-free)	(4.91)
Araban	1.84
Pectin (probably also organic acids)	2.17
Parapectin	0.90
Soluble in alcohol (ash-free)	(2.48)
Prec. by lead subacetate	(1.77)
Araban (?)	0.60
Galactose	1.17
Undetermined (galactose (?))	0.71
Nitrogen	(0.027)
Galactan	(2.23)
Sulphuric acid extract	(40.05)
Ash	(1.36)
Soluble in hot water	1.14
Insoluble in hot water	0.22
Organic matter	(38.69)
Prec. by strong alcohol	(17.87)
[1]Reducing sugars, as dextrose	(16.86)
[1]Invert sugars, as sucrose	3.22
Galactose	(3.78)
Araban, from furfurol distillation	(11.50)
" calculated from reducing sugars	(16.70)
" in warm water extract	3.69
" in diastase extract	2.60
" dissolved by acid, additional	10.41
Nitrogen	(0.418)
Protein	2.61
[1]Undetermined hemicelluloses	16.16

[1] Probably due in part to a component of raffinose.

	Original Material. %
Sodium hydrate extract	(11.99)
Ash	0.20
Organic matter	(11.79)
Reducing sugars after inversion	Trace.
Protein	4.33
Araban	0.47
Lignin acids	6.99
Chlorination extract (lignin)	6.21
Residue after chlorination.	*(12.30)*
Ash	0.98
Cellulose	11.32
	100.52[1]

Summary of Analysis.

Water	9.86
Fats, waxes, resins and colors	1.89
Organic acids[2]	5.23
Tannin	0.12
Reducing sugars, as dextrose	1.21
Invert sugars, as sucrose[3]	7.10
Pectin	2.17
Parapectin	0.90
Hemicelluloses, decomposed by weak acid	16.16
Araban, total	(19.61)
Prec. by alcohol in cold water extract	1.84
Soluble in alcohol in " " "[3]	0.60
" in warm water	3.69
" in diastase extract	2.60
" in acid, additional	10.41
" in alkali, "	0.47
Lignin acids	6.99
Lignin	6.21
Galactan	(8.30)
Cellulose	11.32
Ash	4.08
Protein	6.94
Undetermined	0.73
	100.52

[1] Separate determinations in 80 per cent. alcohol extract exceed total extract by 0.68 per cent.
[2] 4.51 per cent. probably due to raffinose or galactose precipitated by lead acetate.
[3] Probably largely due to the galactose group in raffinose.

Summary.

As already stated the work herewith reported is of a preliminary nature, but certain of the results are very suggestive and well worthy of future study. A very complete analysis of the dried beet pulp has been secured. The pulp contains a large percentage of raffinose; galactan, apparently derived from the galactose of raffinose, was found present (8.30 per cent.), and this galactan was partially soluble in 80 per cent. alcohol, partly in cold water and the balance was hydrolysed by dilute sulphuric acid. The pentosans of beet pulp (arabans) exist as complexes, varying greatly in their resistance to solvents; 2.44 per cent. was soluble in cold water; 16.70 per cent. in dilute sulphuric acid (of this 3.69 per cent. was soluble in warm water and 2.60 per cent. in diastase solution); 1.05 per cent. in dilute alkali and 1.05 per cent. was removed by chlorination. A large part of the sulphuric acid extract (16.16 per cent.) consisted of undetermined hemicelluloses.

A part of the pentosans (2.60 per cent. araban) was soluble in the diastase solution; and 2.63 per cent. dextrose was removed by treatment with warm water in the same manner as in the subsequent diastase treatment. These two facts indicate possible inaccuracies in the present official method for starch, both tending towards high results. Likewise the official crude fiber method gave results 6.44 per cent. too high, the residue after treatment with dilute sulphuric acid and sodium hydrate containing much lignin and appreciable quantities of ash, proteids and pentosans. On the other hand, the chlorination method effectively removed all pentosans and proteids, but 0.98 per cent., or one-fourth of the ash still remained.

The results obtained in this investigation raise doubts as to the advisability of attempting a quantitative determination of the various complex carbohydrates as individual compounds. For instance, in the beet pulp we have apparently six different modifications of araban and at least three of galactan. A determination of total araban or total galactan, in this material at least, would possess but relatively little significance. Further-

more, owing to the complexity of many of the carbohydrates it is by no means certain that a method applicable to one class of materials would be equally useful with others. It would seem, therefore, that with our present knowledge the more rational procedure is to separate the carbohydrates into groups, these groups to be based on their reactions with various solvents rather than on their chemical formulas.

V.

Note on the Determination of Crude Fiber.

BY JOHN PHILLIPS STREET AND WILLIAM P. ALLEN.

The following data were obtained incidental to some work on the carbohydrates of dried beet pulp, and while supplying little new information it is thought desirable to record the results as giving further indication of the imperfections of the official Weende method for crude fiber.

Tollens, E. Schulze, Winterstein and many other workers have shown that the crude fiber obtained by the Weende method is invariably more or less contaminated with pentosans; appreciable amounts of ash and nitrogen are also frequently found. More recently it has been noted that the chlorination treatment[1] removes a substance, or group of substances to which the name "lignin" has been applied. Lignin, while resisting the action of dilute acid, is appreciably affected by dilute alkali, but a part of it resists even prolonged treatment with alkali, and differs from cellulose in forming with chlorin a soluble substance to which Cross and Bevan give the name "lignone chlorid." That this may form a considerable portion of what we at present term crude fiber has been shown by the work reported on an earlier page of this report, in connection with the analysis of dried beet pulp. The residue after treatment with dilute acid and alkali, on chlorination showed a further loss of 6.21 per cent., which was 37 per cent. of the total crude fiber obtained by the Weende method. The present note, however, is concerned more particu-

[1] Cross and Bevan, Cellulose, pp. 95-6.

larly with the amounts of pentosans, ash and nitrogen found in the residue from the acid and alkali treatment of the official method.

Six samples were selected in which four portions were digested as usual with dilute acid and alkali. One residue was dried, weighed, incinerated, and weighed again, the loss being considered crude fiber as in the official method. The second residue was dried and weighed and the ash determined. In the third and fourth after drying and weighing, nitrogen and pentosans were determined respectively. The filtrations were in all cases made through clean cloth and it is believed mechanical losses were reduced to a minimum. The following were the results secured:

FEED.	(*a*) Residue after acid and alkali treatment.	(*b*) Non-volatile ash.	(*c*) Volatile ash.	(*d*) Total ash.	(*e*) Pentosans.	(*f*) Protein (N×6.25).	Fiber by official methods. (*a*)—(*b*)	Fiber with corrections. (*a*)—[(*d*)+(*e*)+(*f*)]
	mgms.	mgms.	mgms.	mgms.	mgms.	mgms.	mgms.	mgms.
Jersey Mixed Feed	351.4	4.2	3.1	7.3	38.8	2.5	347.2	302.8
Fourex Distillers' Grains	261.7	6.2	6.6	12.8	20.0	12.5	255.5	216.4
Continental Gluten Feed	186.6	3.4	1.3	4.7	13.2	6.3	183.2	162.4
Alfalfa Meal	667.4	11.4	2.0	13.4	101.2	7.5	656.0	545.2
Climax Distillers' Grains	224.9	3.6	2.2	5.8	17.4	10.0	221.3	191.7
Cottonseed Meal	218.7	1.4	6.3	7.7	35.6	7.5	217.3	167.9

It should be noted that in the official method the process of incineration, as shown by the above figures, removes appreciable quantities of volatile ash. In the analyses above reported these amounts are not large save in the case of Fourex Grains and Cottonseed Meal, where 6.6 and 6.3 mgms., or 0.33 and 0.32 per cent., were obtained respectively. The total ash not removed by the dilute acid and alkali treatment ranged from 4.7 to 13.4 mgms., or from 0.24 to 0.67 per cent. All the residues contained pentosans, ranging from 13.2 to 101.2 mgms., or from 0.66 to

5.06 per cent. The amounts of protein found in the residues were small in all the samples, the actual nitrogen varying from 0.02 to 0.10 per cent. The total correction for ash, pentosans and proteids ranges from 24.2 to 122.1 mgms., or from 1.21 to 6.11 per cent., giving percentages of 15.14, 10.82, 8.12, 27.27, 9.59 and 8.40 against 17.36, 12.78, 9.16, 32.80, 11.07 and 10.87 respectively as obtained by the official method. These differences are much too wide for a reliable quantitative method, and when the undoubted further contamination of the residue, particularly that from alfalfa meal, with lignin compounds is also considered, the necessity for further work on our crude fiber methods is clearly emphasized.

VI.

BUCKWHEAT PRODUCTS.

Proposed Standards of Composition.

BY JOHN PHILLIPS STREET.

The great variability in composition of the various buckwheat milling products and the confusion existing in the trade in the use of the terms middlings, bran and feed, led the writer to enter into correspondence with several of the leading buckwheat millers to determine the reasons for these variations. It was found that widely different systems of milling were in general use, and that the practice of millers, as regards the hard, black hulls was variable, some mixing the hulls in greater or less proportion with the middlings under the name of "bran," while others used them entirely for fuel. It is evident, therefore, that under present conditions little uniformity in composition can be expected in these products.

Two years ago[1] the writer made a careful separation of the various parts of the buckwheat grain and analysed and found that the grain yielded 64 per cent. of flour, 16 per cent. of middlings and 20 per cent. of hulls. The middlings is characterized by its high content of protein, fat and ash and its low fiber; the hulls, on the other hand, contain little protein and consist of

[1] New Jersey Expt Stat. Rept 1904, p. 106.

nearly one-half fiber: the flour contains a very high percentage of nitrogen-free extract, and but a trace of fiber. From these data it is evident that the analysis of a buckwheat product will show very clearly its source. A high percentage of fiber is certain indication of the presence of hulls. A temporary classification of buckwheat products, regardless of the names under which they were sold, was made by this Station in 1904 as follows: "Middlings" includes those samples containing more than 25 per cent. of protein; "bran," those containing less than 25 per cent. of protein and small amounts of crude fiber; "feed," those containing less than 25 per cent. of protein and large amounts of crude fiber; samples containing less than 5 per cent. of protein are classed as "hulls."

During the past year the writer has been engaged in the preparation of standards for buckwheat products in connection with the Committee on Food Standards of the Association of Official Agricultural Chemists. In preparing these standards all available authentic analyses of an American source have been tabulated and given careful consideration. The names under which the products were sold have been entirely disregarded, and they have been grouped in accordance with the above classification. The variations in moisture were naturally wide and all analyses have been recalculated to a uniform water content based on the average amount found in the analyses as published. These moisture figures are in a sense more or less arbitrary, but no other way seemed practicable. The grain and milling products sold soon after harvest would naturally show a higher moisture content, but the figures as given, it is believed, represent the average product as it comes into the market for sale. In this connection attention should be again called to the fact that the presence of excessive moisture introduces conditions very favorable to the growth of molds, which, as the writer has already shown[1] in corn meal, cause a cleavage of fat and a serious loss of this valuable compound. A similar effect was noticed in the case of two samples of buckwheat middlings analysed at this Station in 1904.[2] These samples contained

[1] New Jersey Expt. Stat. Rept. 1903, pp. 123-147.

[2] New Jersey Expt. Stat. Rept. 1904, p. 107.

18.19 and 16.06 per cent. moisture, 4.59 and 4.34 per cent. fat and 36.76 and 33.75 per cent. protein, respectively. The first sample, after an interval of fifty-two days, was retested for fat, and showed but 2.42 per cent., indicating a still further loss of nearly one-half. Inasmuch as excessive moisture therefore encourages a loss of fat, it would seem that this moisture, while not an adulteration in the strictest sense, should be recognized as *injurious and the sale of only properly-cured or dried materials* should be encouraged.

It will be noticed that under the proposed standard for middlings has been included "the ratio of ether extract to protein should not be less than 1:3.6 or more than 1:3.9." This is based on the examination of many analyses, and is intended to serve especially in samples like those referred to above. The ratio of fat to protein in these samples is 1:8.0 and 1:7.8, respectively, and shows conclusively that the fat is too low for a sample of good quality. It is believed that this ratio will be helpful to analysts, giving as it does direct information without the use of the microscope and making unnecessary the preparation of mold cultures.

After fixing the standards proposed below a copy of the proposed classification and standards was sent to leading buckwheat millers and millers' associations in the East and West, and in all cases the classification was accepted as fully covering the ground and only criticisms concerning minor points were offered. In *defining the various buckwheat products the definitions have* been based on those given by the Pennsylvania Experiment Station with such modifications as the proposed classification made necessary. The standards are based on the analyses of 42 samples of buckwheat grain, 67 of middlings, 26 of bran, 19 of feed, 14 of hulls and 4 of straw, 172 analyses in all.

PROPOSED STANDARDS.

Buckwheat and Products.

Buckwheat milling products consist of the following classes:

1. The flour, including the starch with as little as possible of the other layers.

2. *The middlings and bran, including varying proportions o: the seed coat*, the aleurone layer and more or less starch.

3. The hulls, comprising the outer epidermis, the woody layer, the less-hardened adjacent layer and the inner epidermis

4. The feed, comprising the hulls and bran, with more or less of the outer hull removed.

1. Buckwheat grain is the fully matured, clean, sound, air-dry seed of *Fagopyrum esculentum*. It should contain not more than twelve and one-half (12.5) per cent. of moisture, not less than one and one-half (1.5) per cent. of nitrogen, and not more than two and one-quarter (2.25) per cent. of ash.

2. Buckwheat middlings should contain not more than twelve (12) per cent. of moisture, not less than four and sixteen hundredths (4.16) per cent. of nitrogen, not less than seven and one-quarter (7.25) per cent. of ether extract, and not more than six and one-half (6.5) per cent. of ash. In pure middlings the ratio of the ether extract to the protein should not be less than 1:3.6 or more than 1:3.9.

3. Buckwheat bran should contain not more than twelve and one-quarter (12.25) per cent. of moisture, not less than three and one-tenth (3.1) per cent. of nitrogen, not more than four and three-quarters (4.75) per cent. of ash, and not more than four and one-half (4.5) per cent. of fiber.

4. Buckwheat feed should contain not more than eleven (11) per cent. of moisture, not less than two and fifty-six hundredths (2.56) of nitrogen, not more than five and one-half (5.5) or less than three and one-half (3.5) per cent. of ash, and not more than twenty (20) per cent. of fiber.

5. Buckwheat straw should contain not more than ten and one-half (10.5) per cent. of moisture, not less than fifty-six hundredths (0.56) per cent. of nitrogen, and not less than five (5) per cent. of ash.

6. Buckwheat hulls should contain not more than nine (9) per cent. of moisture, not less than one-half (0.50) per cent. of nitrogen, and not more than two and one-half (2.50) per cent. of ash.

VII. Inspection of Paris Green.

The results of the first inspection of Paris green sold in the State, under the law of April 9th, 1906, were published in Bulletin 195.

Summary.

Thirty samples were analysed, all but three of which were guaranteed as required by law.

Twenty samples were of undoubted purity.

No sample contained over 3.50 per cent. of water-soluble arsenious oxid, but one contained nearly 3 per cent., and from the proportionately small amount of copper oxid present, the addition of white arsenic to this sample seemed probable.

Three samples failed to meet the legal requirement of 50 per cent. of arsenic in combination with copper, one of these containing only about one-half of the required quantity, and being grossly adulterated with sugar.

Twenty-nine samples contained, on the average, 57.44 per cent. of total arsenious oxid and 55.61 per cent. of arsenious oxid combined with copper.

The requirements of the law are most moderate, and no manufacturer using care in the manufacture of his product should have difficulty in adhering to the standard.

INVESTIGATIONS RELATIVE TO THE USE OF NITROGENOUS MATERIALS.*

BY EDWARD B. VOORHEES AND JACOB G. LIPMAN.

The progress of these investigations, reported from year to year since 1899 is gaining in interest, because of the constantly increasing number of crops available for comparison. The crops of the first rotation, 1898–1902, allowed a study of certain crops produced on the same soil, differently fertilized. The crops of the second rotation, 1903–1907, permit a similar study,

*See N. J. Sta. Reports for 1899, 1900, 1901, 1902, 1903, 1904 and 1905.

and in addition to that a comparison of the same crops, and on the same soils modified to a greater or less extent in the five years intervening between the corresponding crops of the first and second rotations. The wheat crop of 1906, whose yields are recorded in this paper, shows distinctly the modifications in question, and it was, therefore, deemed best, for the purposes of comparison, to present here, also, the average yields for the wheat crop of 1901. Proper allowance should be made in the comparison of the data tabulated in the following pages for the climatic factor whose influence is particularly marked in crops with a comparatively long growing season. There is no doubt that the rather heavy snowfall of 1901 was a disturbing factor of considerable significance. The drifting snow accumulated to a greater extent in some cylinders than in others. It was partly converted into ice and thawed out very slowly. This introduced differences in the moisture content of the soils, which persisted well into the growing season. On the other hand, the season of 1906 was comparatively free from snow, and there was no considerable accumulation of it in the cylinders. Hence the seasonal influences were not of as great moment in 1906 as they were in 1901, in affecting the uniformity of plant-growth in the different cylinders. As the result of this circumstance, it was not necessary to eliminate many data in the computation of the averages in the several series, as was done in 1901. The modifications introduced in the course of time by divergent soil treatment should also receive proper consideration. This will be noted in the comparative study of the yields of dry matter and of nitrogen for the two seasons under consideration.

The Wheat Crop of 1906.

The Manures Used.

As in preceding reports, the composition of the manures used in the experiment is reported, and for the sake of comparison the average composition of eight other samples is also given, as may be seen from the analyses reported below.

:HE COMPOSITION OF THE SOLID AND OF THE SOLID AND LIQUID PORTIONS OF COW MANURE, FRESH.

The fresh manures collected in the customary manner had the ollowing composition :

Fresh Manure, Solid.

	1905-6. %	Average of eight other samples. %
Water	84.455	85.023
Ash	2.001	2.241
Organic matter	13 444	12.736
Nitrogen (total)	0.365	0.340
" soluble in H_2O	0.037	0.062
" as nitrate	......	0.005
" as ammonia	0.010	0.022
" as soluble organic	0.027	0.035
" as insoluble organic	0.328	0.278
Phosphoric acid	0.252	0.336
Potash	0.096	0.196

The sample of 1905–1906 was somewhat richer in total nitro- ;en than the average of the other samples. It was poorer in vater-soluble and ammonia nitrogen, poorer in phosphoric acid, nd very markedly poorer in potash. On the other hand, the ample of 1905–1906 was richer in organic matter than the aver- ge of the other samples.

Fresh Manure, Solid and Liquid.

	1905-6. %	Average of eight other samples. %
Water	88.930	87.405
Ash	2.606	2.046
Organic matter	8.464	10.549
Nitrogen (total)	0.566	0.444
" soluble in H_2O	0.362	0.230
" as nitrate	......	0.005
" as ammonia	0.181	0.109
" as soluble organic	0.181	0.116
" as insoluble organic	0.204	0.214
Phosphoric acid	0.183	0.265
Potash	0.546	0.422

Compared with the average of eight other samples, that of 1905–1906 has a higher content of water and ash, and a lower content of organic. It has, likewise, a higher content of total, water-soluble and ammonia nitrogen, a lower content of phosphoric acid, and a higher content of potash.

THE COMPOSITION OF THE SOLID AND OF THE SOLID AND LIQUID PORTIONS OF COW MANURE, LEACHED

The fresh manures were exposed to the leaching action of rain in the customary manner from July 12th until September 29th, 1905. The composition of the manures, both before and after leaching, is given below. During that time the 100 pounds of manure were reduced to sixty-four pounds in the case of the solid manure, and to forty-seven pounds in the case of the solid and liquid manure. The losses sustained may be computed from the analyses of the materials, both before and after leaching, when taken in connection with the initial and final weights of the manures in question.

Solid, Fresh, Previous to and After Leaching.

	Fresh. %	Leached. %
Water	82.182	82.765
Ash	2.005	2.365
Organic matter	15.813	14.870
Nitrogen (total)	0.326	0.323
" soluble in H_2O	0.061	0.018
" as nitrate	....	Trace
" as ammonia	0.030	Trace
" as soluble organic	0.031	0.018
" as insoluble organic	0.265	0.305
Phosphoric acid	0.338	0.395
Potash	0.392	0.165

Solid and Liquid, Fresh, Previous to and After Leaching.

	Fresh. %	Leached. %
Water	87.322	82.699
Ash	1.758	1.773
Organic matter	10.920	15.528
Nitrogen (total)	0.220	0.336
" soluble in H_2O	0.047	0.024
" *as nitrate*	....	*Trace*
" as ammonia	0.004	0.012
" as soluble organic	0.043	0.012
" as *insoluble* organic	*0.173*	*0.312*
Phosphoric acid	0.177	0.194
Potash	0.366	0.161

The corresponding analyses for the preceding years have been fully discussed in previous reports, making it unnecessary to discuss again the present data. It may be pointed out here, however, that the exposure involves not merely a loss of soluble salts, but also of moisture, since the leached samples are usually drier than the corresponding fresh samples. The reduced moisture content, as well as the elimination of the bulk of the soluble salts, influence materially the bacterial changes in the manure, for with retarded bacterial development the losses from fermentation must of necessity be smaller than those in large piles of manure. Retarded fermentation in its turn involves a retarded solution of the insoluble constituents, and hence a diminished loss from the leaching action of rain. It appears, therefore, that *under the conditions of the experiments, the losses involved* are not exaggerated, notwithstanding the comparatively small amounts of manure under investigation.

The Experiment Plant.

The accompanying diagram shows the arrangement of the several cylinders, and is inserted here to add clearness to the experimental data presented below.

Diagram of Experiment.

Series.	A	B	C
1. Check	○	○	○
2. Minerals	○	○	○
3. Manure, solid, fresh	○	○	○
4. Manure, solid and liquid, fresh	○	○	○
5. Manure, solid, leached	○	○	○
6. Manure, solid and liquid, leached	○	○	○
7. Nitrate of soda, 5 gms	○	○	○
8. Nitrate of soda, 10 gms	○	○	○
9. Manure, solid, fresh; nitrate, 5 gms	○	○	○
10. Manure, solid, fresh; nitrate, 10 gms	○	○	○
11. Manure, solid and liquid, fresh; nitrate, 5 gms	○	○	○
12. Manure, solid and liquid, fresh; nitrate, 10 gms	○	○	○
13. Manure, solid, leached; nitrate, 5 gms	○	○	○
14. Manure, solid, leached; nitrate, 10 gms	○	○	○
15. Manure, solid and liquid, leached; nitrate, 5 gms	○	○	○
16. Manure, solid and liquid, leached; nitrate, 10 gms	○	○	○
17. Sulphate of ammonia	○	○	○
18. Dried blood	○	○	○
19. Manure, solid, leached; sulphate of ammonia	○	○	○
20. Manure, solid, leached; dried blood	○	○	○

Application of Manures and Fertilizers.

A few days after the residual corn crop of 1905 was harvested, the cylinder soils were dug up and the manures and fertilizers were applied in the customary manner on October 4th, 1905. The usual precautions were taken in securing uniform distribution of these materials.

Amounts Applied.

It was the aim to have the different kinds of manure applied uniform in amount, and slightly greater than that used in ordinary farm practice, and corresponding with that frequently used in market gardening. The application was in no case so excessive as to render the conditions different from those observed in good farm practice, being at the rate of sixteen tons per acre.

In the case of the concentrated nitrogenous fertilizers, the nitrate was applied in the fall, at the rate of 1¼ gms. per cylinder in series 7, 9, 11, 13 and 15; and at the rate of 2½ gms. in series 8, 10, 12, 14 and 16. The ammonium sulphate in series 17 and 19 was applied at the rate of 2 gms. per cylinder; and the dried blood in series 18 and 20, at the rate of 15 gms. per cylinder. These applications were equivalent to one-quarter of the total in the case of the nitrate and the ammonium sulphate. The 15 gms. of the dried blood represented the entire quantity to be applied. The quantities of manure applied were: Of solid, fresh, 2 lbs., 7 oz. = 4.05 gms. nitrogen; of solid and liquid, fresh, 1 lb., 9 oz. = 4.01 gms. nitrogen; of solid, leached, 2 lbs., 11 oz. = 4.05 gms. nitrogen; of solid and liquid, leached, 2 lbs., 12 oz. = 4.03 gms. nitrogen.

On April 11th, 1906, series 7, 8, 9, 10, 11, 12, 13, 14, 15 and 16, received an additional application of 3¾ gms. of nitrate, and series 17 and 19 an additional application of 6 gms. of ammonium sulphate per cylinder. On May 4th, 1906, series 8, 10, 12, 14 and 16 received a further application of 3¾ gms. of nitrate per cylinder. It will be seen thus, that where 5 gms. of nitrate were used, 1¼ gms. were applied in October and 3¾ gms. in April. Where 10 gms. of nitrate were used, 2½ gms. were applied in October,

$3\frac{3}{4}$ gms. in April, and $3\frac{3}{4}$ gms. in May. Where 8 gms. of ammonia sulphate (equivalent to 10 gms. of sodium nitrate) were used, 2 gms. were applied in October and 6 gms. in April. Where 15 gms. of dried blood (equivalent to 10 gms. of sodium nitrate) were used, the entire amount was applied in October. The manures were all applied in the fall in the manner already described.

The Crop Grown.

The crop grown in the cylinder soils was wheat, followed by timothy. One hundred grains of winter wheat were planted in each soil on October 4th. The germination was satisfactory throughout, although considerably retarded in series 1 and 2. Good growth was made by the young wheat plants in the fall. After the arrival of warm weather in the spring, the growth was quite rapid, showing a gratifying uniformity in the parallels of each series. Later in the season, the wheat plants were somewhat affected by rust, yet it is not believed that the injury was in any case of marked extent.

In calculating the yield, the average of the three plots in any one series is usally taken, and, by substracting the average yield on the check plots, the yield due to the particular manure or fertilizer is obtained. Thus, by substracting the average yield on series 2 from that on series 8, the yield due to the ten grams of nitrate applied on the latter series is obtained. It is necessary, of course, to assume here that the amount of nitrogen obtained from the soil itself by the crops on series 8 is equal to the amount of nitrogen obtained from the soil by the crops on series 2, where no nitrogen is applied. As a matter of fact, the average amount of nitrogen withdrawn from the soil itself on series 8 is never equal to, but always greater than, the average amount of nitrogen withdrawn from the soil on series 2. The reason for this *is evident, if we consider that the soil nitrogen becomes* soluble very gradually, and the thoroughness with which this soluble nitrogen is utilized by the growing crop depends on the root development of the individual plants. It is quite apparent that the plants on series 2 will grow but slowly, since the amount

of nitrogen placed at their disposal is very meager. In consequence of this limited growth the root development of the plants will be rather limited, and therefore not capable of appropriating all, or most of, the nitrogen, rendered soluble in the course of the season, and particularly in the early part of it. On the other hand, the nitrate nitrogen offered to the plants on series 8 will make possible a good root development and a more thorough utilization of the nitrogen derived from the soil itself. Moreover, the sodium nitrate will exert a solvent action on the soil humus over and above that exerted by the substances applied on series 2. Thus it will be seen that the average amount of nitrogen credited to the nitrate on series 8 will partly consist of the nitrogen derived from the soil in excess of the average amount derived from the soil of series 2. Since the soil nitrogen becomes soluble but slowly, the amount obtained by the growing crop will be directly proportional to the length of the growing season, a circumstance that should not be left out of consideration in the study of the yields on the different series and in different seasons.

It should further be remembered in this connection that the root residues in the soils of series 8, or in any of the soils where nitrogenous materials were applied, are much greater than those in series 2, representing in part a portion of the nitrogen applied to preceding crops. These root residues being of rather recent origin, are not as resistant to decay as are the organic remains of older date. This fact finds striking confirmation in the experience at Rothamsted. "It must not be supposed, however," says Hall,* "that dressings of manures like nitrate of soda and sulphate of ammonia, which so readily wash away as nitrates, are entirely without action on succeeding crops. Because of the very fact that they cause a large growth, there is left behind in the soil a correspondingly large development of root and stubble, which will decay for the benefit of succeeding crops."

* The Book of the Rothamsted Experiments, p. 226.

The Results of the Wheat Experiment, 1906.

The crop was harvested early in July, and the air-dry matter and nitrogen determined separately in the grain and straw. The accompanying table shows the actual dry matter, both in the straw and the grain, from each series, the percentage of nitrogen found, the gain in nitrogen due to the materials added, and the percentage of the applied nitrogen recovered. In all cases the net gains in the different series are derived by substracting the average gain obtained in series 2, upon which minerals only were applied, from the average gain on that particular series.

TABLE 1.

Results of the Wheat Experiment, 1906.

SERIES.	Nitrogen applied.	GRAIN.			STRAW.			TOTAL CROP.				Per cent. of nitrogen recovered.	Average per cent. of nitrogen recovered.
		Dry matter in crop.	Nitrogen in dry matter.	Nitrogen in crop.	Dry matter in crop.	Nitrogen in dry matter.	Nitrogen in crop.	Dry matter in crop.	Nitrogen in dry matter.	Nitrogen in crop.	Increase over check plot.		
		gms.	%	gms.	gms.	%	gms.	gms.	%	gms.			
1 A	....	15.0	2.092	0.313	41	0.752	0.307	56	1.104	0.620	....	....	....
1 B	....	12.0	2.223	0.266	32	0.881	0.282	44	1.245	0.548	....	....	....
1 C	....	7.0	2.449	0.171	28	1.059	0.296	35	1.331	0.467	....	....	....
2 A	....	25.0	1.681	0.420	58	0.369	0.214	83	0.764	0.634	....	....	....
2 B	....	27.0	1.719	0.464	61	0.386	0.235	88	0.794	0.699	(0.747)	....	....
2 C	....	37.0	1.684	0.623	87	0.328	0.285	121	0.732	0.908	....	....	....
3 A	4.05	74.0	1.687	1.248	161	0.318	0.512	235	0.748	1.760	1.013	25.0	....
3 B	"	78.0	1.687	1.316	153	0.311	0.476	231	0.776	1.792	1.045	25.8	25.9
3 C	"	75.0	1.770	1.327	162	0.314	0.509	237	0.775	1.836	1.089	26.9	....
4 A	4.01	100.0	1.729	1.729	219	0.301	0.659	319	0.745	2.388	1.641	40.9	....
4 B	"	103.0	1.771	1.824	213	0.318	0.677	316	0.791	2.501	1.754	43.7	43.6
4 C	"	101.0	1.845	1.863	225	0.325	0.731	326	0.795	2.594	1.847	46.1	....
5 A	4.05	74.0	1.719	1.272	152	0.325	0.494	226	0.781	1.766	1.019	25.1	....
5 B	"	77.0	1.720	1.324	163	0.284	0.463	240	0.744	1.787	1.040	25.7	28.3
5 C	"	83.0	1.896	1.574	186	0.301	0.560	269	0.793	2.134	1.387	34.2	....
6 A	4.03	71.0	1.719	1.220	142	0.307	0.436	213	0.777	1.656	0.909	22.5	....
6 B	"	66.0	1.696	1.119	139	0.301	0.418	205	0.750	1.537	0.790	19.6	21.0
6 C	"	92.0	1.770	1.628	199	0.362	0.720	291	0.807	2.348	1.601	39.7	....
7 A	0.78	60.0	1.562	0.937	126	0.284	0.357	186	0.696	1.294	0.547	70.1	....
7 B	"	64.0	1.586	1.015	130	0.301	0.391	194	0.725	1.406	0.659	87.0	82.0
7 C	"	62.0	1.568	0.972	136	0.328	0.446	198	0.716	1.418	0.671	88.9	....

TABLE I.—Continued.

Results of the Wheat Experiment, 1906.

Series.	Nitrogen applied.	Grain. Dry matter in crop.	Grain. Nitrogen in dry matter.	Grain. Nitrogen in crop.	Straw. Dry matter in crop.	Straw. Nitrogen in dry matter.	Straw. Nitrogen in crop.	Total Crop. Dry matter in crop.	Total Crop. Nitrogen in dry matter.	Total Crop. Nitrogen in crop.	Total Crop. Increase over check plot.	Per cent. of nitrogen recovered.	Average per cent. of nitrogen recovered.
		gms.	%	gms.	gms.	%	gms.	gms.	%	gms.			
8 A	1.55	85.0	1.657	1.378	154	0.368	0.568	239	0.814	1.946	1.199	77.3	
8 B	"	85.0	1.664	1.419	159	0.345	0.548	244	0.806	1.967	1.220	78.7	85.2
8 C	"	92.0	1.762	1.621	182	0.369	0.671	274	0.836	2.292	1.545	99.7	
9 A	4.83	105.0	1.762	1.850	192	0.325	0.624	297	0.833	2.474	1.727	35.8	
9 B	"	110.0	1.732	1.905	206	0.325	0.669	316	0.811	2.574	1.827	37.9	36.2
9 C	"	98.0	1.794	1.758	189	0.359	0.678	287	0.849	2.436	1.689	35.0	
10 A	5.60	110.0	1.815	1.996	222	0.393	0.872	332	0.864	2.868	2.121	37.9	
10 B	"	127.0	1.762	2.240	211	0.345	0.728	338	0.878	2.968	2.221	39.7	40.3
10 C	"	118.0	1.908	2.251	225	0.410	0.922	343	0.925	3.173	2.426	43.3	
11 A	4.79	127.0	1.920	2.438	255	0.328	0.836	382	0.857	3.274	2.527	52.8	
11 B	"	132.0	1.845	2.435	267	0.335	0.894	399	0.834	3.329	2.582	53.9	51.3
11 C	"	114.0	1.881	2.144	236	0.366	0.864	350	0.859	3.008	2.261	47.2	
12 A	5.56	122.0	2.064	2.518	248	0.376	0.932	370	0.932	3.450	2.703	48.6	
12 B	"	135.0	1.860	2.511	233	0.386	0.899	368	0.927	3.410	2.663	47.9	48.2
12 C	"	148.0	2.247	3.325	283	0.468	1.324	431	1.079	4.649	3.962	70.2	
13 A	4.83	95.0	1.800	1.710	190	0.335	0.646	285	0.826	2.356	1.609	33.3	
13 B	"	87.0	1.780	1.549	200	0.362	0.724	287	0.792	2.273	1.526	31.6	33.5
13 C	"	92.0	1.881	1.730	199	0.369	0.734	291	0.849	2.464	1.717	35.5	
14 A	5.60	120.0	2.041	2.449	212	0.410	0.869	332	1.000	3.318	2.571	45.9	
14 B	"	106.0	1.800	1.908	200	0.369	0.738	306	0.865	2.646	1.899	33.9	38.7
14 C	"	110.0	1.815	1.996	195	0.400	0.780	305	0.910	2.776	2.029	36.2	

TABLE I.—Continued.

Results of the Wheat Experiment, 1906.

Series.	Nitrogen applied.	Grain. Dry matter in crop.	Grain. Nitrogen in dry matter.	Grain. Nitrogen in crop.	Straw. Dry matter in crop.	Straw. Nitrogen in dry matter.	Straw. Nitrogen in crop.	Total Crop. Dry matter in crop.	Total Crop. Nitrogen in dry matter.	Total Crop. Nitrogen in crop.	Total Crop. Increase over check plot.	Per cent. of nitrogen recovered.	Average per cent. of nitrogen recovered.
		gms.	%	gms.	gms.	%	gms.	gms.	%	gms.			
15 A	4.81	82.0	1.766	1.448	163	0.335	0.546	245	0.814	1.994	1.247	25.9	
15 B	"	79.0	1.833	1.448	167	0.345	0.576	246	0.823	2.024	1.277	26.5	28.7
15 C	"	95.0	1.765	1.677	198	0.352	0.697	298	0.803	2.374	1.627	33.8	
16 A	5.58	107.0	1.814	1.941	208	0.362	0.753	315	0.855	2.694	1.947	34.9	
16 B	"	102.0	1.732	1.767	191	0.359	0.686	293	0.837	2.453	1.706	30.6	32.8
16 C	"	103.0	1.800	1.854	192	0.383	0.735	295	0.878	2.589	1.842	33.0	
17 A	1.62	40.0	2.009	0.804	100	0.468	0.468	140	0.909	1.272	0.525	32.4	
17 B	"	41.0	1.896	0.777	85	0.495	0.421	126	0.951	1.198	0.451	27.8	33.5
17 C	"	49.0	1.913	0.937	104	0.444	0.462	153	0.914	1.399	0.652	40.2	
18 A	1.57	47.0	1.696	0.797	109	0.348	0.379	156	0.754	1.176	0.429	27.3	
18 B	"	48.0	1.664	0.799	96	0.301	0.289	144	0.756	1.088	0.341	21.7	25.7
18 C	"	48.0	1.696	0.814	112	0.335	0.375	160	0.743	1.189	0.442	28.1	
19 A	5.67	83.0	1.809	1.501	169	0.362	0.612	252	0.838	2.113	1.366	24.1	
19 B	"	94.0	1.824	1.714	164	0.359	0.589	258	0.892	2.303	1.556	27.4	26.8
19 C	"	83.0	1.949	1.618	184	0.413	0.760	267	0.891	2.378	1.631	28.8	
20 A	5.62	88.0	1.794	1.579	190	0.345	0.655	278	0.804	2.234	1.487	26.5	
20 B	"	89.0	1.855	1.651	174	0.307	0.534	263	0.831	2.185	1.438	25.6	27.1
20 C	"	88.0	1.886	1.660	198	0.359	0.711	286	0.829	2.371	1.624	28.9	

Average Amount of Dry Matter in Crop, 1906.

Series.	Grain. gms.	Straw. gms.	Total. gms.	Proportion of Grain to Straw.
1	11.3	33.7	45.0	1:2.98
2	29.7	68.7	98.4	1:2.31
3	75.7	158.7	234.4	1:2.10
4	101.3	219.0	320.3	1:2.16
5	78.0	167.0	245.0	1:2.14
6	76.3	160.0	236.3	1:2.10
7	62.0	130.7	192.7	1:2.11
8	87.3	165.0	252.3	1:1.89
9	104.3	195.7	300.0	1:1.88
10	118.3	219.3	337.6	1:1.85
11	124.3	252.7	377.0	1:2.03
12	135.0	254.7	389.7	1:1.89
13	91.3	196.3	287.6	1:2.15
14	112.0	202.3	314.3	1:1.81
15	85.3	176.0	261.3	1:2.06
16	104.0	197.0	301.0	1:1.89
17	43.3	96.3	139.6	1:2.22
18	47.7	105.7	153.4	1:2.22
19	86.7	172.3	259.0	1:1.99
20	88.3	187.3	275.6	1:2.11

Average Amount of Dry Matter in Crop, 1901.

Average of Two Marked with an *.

Series.	Grain. gms.	Straw. gms.	Total. gms.	Proportion of Grain to Straw.
1	31.1*	50.7*	81.8	1:1.63
2	39.9*	60.0*	99.9	1:1.50
3	97.0*	176.0*	273 0	1:1.81
4	100.4*	189.7*	290.1	1:1.89
5	94.0*	164.4*	258.4	1:1.75
6	81.5*	131.1*	212 6	1:1.61
7	75.7*	131.4*	207.1	1:1.74
8	123.4	205.4	328.8	1:1.66
9	132.0*	228.1*	360.1	1:1.73
10	168.2*	273.8*	442.0	1:1.63
11	134.8*	245.9*	380.7	1:1.78
12	155.9	281.7	437 6	1:1.81
13	127.4	211.9	339.3	1:1.66
14	151.1*	245.0*	396.1	1:1.62
15	126.4*	204.5*	330.9	1:1.62
16	173.4*	279.3*	452.7	1:1.63
17	114.6*	184.7*	299.3	1:1.62
18	98.6*	159.1*	257.7	1:1.61
19	150.3	239.9	390.2	1:1.59
20	120.0*	205.7*	325.7	1:1.71

In examining the yields of dry matter in the crop of 1906, we find a distinctly larger yield in series 2, as compared with that of series 1. We find, likewise, the distinct superiority of the solid and liquid, fresh, in series 4 over the solid, fresh, in series 3. The differences in the case of the leached manures are slight and in favor of the solid portion in series 5. The influence of the larger applications of nitrate, as compared with the corresponding smaller application is quite perceptible. We thus note a higher yield of both grain and straw in series 8, as compared with the corresponding yields in series 7. The same is true of series 10 and 9, 12 and 11, 14 and 13, 16 and 15. It is quite instructive to note in this connection that the increase did not affect the straw to the same extent as it affected the grain. This is best brought out by the last column of the table, showing the proportion of grain to straw in the several series. It will be noted that the proportion of grain to straw in series 7 is 1:2.11 and in series 8, 1:1.89; in series 9, it is 1:1.88, and in series 10, 1:1.85; in series 11, it is 1:2.03, and in series 12, 1:1.89; in series 13, it is 1:2.15, and in series 14, 1:1.81; in series 15, it is 1:2.06, and in series 16, 1:1.89. In other words, the double portion of nitrate, whether used alone or in combination with any of the manures, favored the production of grain in greater degree than did the corresponding single portion. This may be interpreted to mean that in none of the soils was there a greater amount of nitrogen supplied than could be properly assimilated by the plants, and that in all cases its bulk was used up sufficiently early in the season to preclude a retarded maturation and a disproportionate growth of straw. At the same time, there was enough of a reserve of nitrogen, stored in the straw of series 8, 10, 12, 14 and 16, to permit of a better development of grain than was possible in series 7, 9, 11, 13 and 15. The same fact is also brought out in series 17 and 19, and in series 18 and 20, where ammonium sulphate and dried blood were used alone or in combination with solid manure, leached. We may note here, also, that the nitrate nitrogen in series 8 proved strikingly superior to the equivalent quantities of ammonium sulphate and dried blood nitrogen, respectively, in series 17 and 18. Compar-

ing the different manures, when used in combination with nitrate we note that also here the solid and liquid, fresh, is superior to the solid, fresh, and the solid, leached, superior to the solid and liquid, leached. Thus there was a total yield of dry matter in series 9 of 300.0 gms. as against a corresponding yield of 377.0 gms. in series 11. Similarly, the yields in series 10 and 12 were 337.6 gms. and 389.7 gms., respectively. The relations pointed out above hold good, also, in series 13 and 15, and in series 14 and 16. Comparing series 14, where the solid, leached, manure was used in combination with 10 gms. of nitrate, with series 19 and 20, where the same manure was used in combination with ammonium sulphate and dried blood, respectively, we find a very marked difference in favor of the nitrate. Indeed, the yields of grain in series 19 and 20, namely, 86.7 gms. and 88.3 gms., respectively, are not much greater than the corresponding yield in series 5, where the same manure was used alone. The same is true, also, of the yields of straw in these series, giving a total yield of 245.0 gms. of dry matter for series 5, and corresponding yields of 259.0 gms. and 275.6 gms., respectively, for series 19 and 20. Both when used alone, and in combination with the manure, the dried blood nitrogen gave slightly greater returns than did the corresponding applications of ammonium sulphate nitrogen.

Another fact worthy of mention here is the high proportion of straw to grain in series 1 and 2. In case of the former, this is explained by the lack of available phosphoric acid in the soil, where it has become the controlling factor of growth. The proportionally large amounts of nitrogen gathered in the straw in the earlier part of the season could not be utilized fully for the production of grain, because of the deficiency of phosphoric acid. In series 2, there was an abundance of the mineral elements of plant-food, but the nitrogen became available so slowly, and in quantities so small, as to preclude normal development, hence it was not utilized to best advantage in the latter part of the season for the production of grain. A comparison of the corresponding yields in 1901 and 1906 will show the decided reduction of the crop-producing power of the cylinder soils. In

series 1, we find a reduction from 31.1 gms. of grain to 11.3 gms., and a reduction from 50.7 gms. of straw to 33.7 gms. The reduction in the total yield of series 2 was slight, and was due entirely to the falling off in the yield of grain, whereas in the case of the straw the crop of 1906 was actually greater than that of 1901. The falling off in the yield of both grain and straw in series 3 was rather more marked. In series 4 there was a gain in the yield of straw, and a very slight gain in the yield of grain. In series 5 and 6 there was a marked falling off in the yield of grain, and a gain in the yield of straw. In all of the other series there was a falling off in the yield of grain, and with one exception (series 11), also in the yield of straw. The most striking reduction in the yields of grain, as well as of straw, is apparent in the soils where ammonium sulphate and dried blood were used alone, or in combination with manure. We thus find a reduction in the yield of grain from 114.6 gms. to 43.3 gms. in series 17, and a corresponding reduction from 98.6 gms. to 47.7 gms. in series 18. The yield of straw showed a reduction from 159.1 gms. to 105.7 gms. in series 18. Furthermore, the relations in the yields of these two series are reversed, since in 1906 the crops in series 18 were larger than those in series 17, whereas in 1901 the latter series showed the higher returns. The highest proportion of straw to grain is found, in 1901, in series 4, and the lowest in series 2. In 1906, the highest proportion of grain to straw is found in series 1, and the lowest in series 14. The smallest difference for the two seasons occurs in series 12, where the proportion of straw to grain was 1.81:1 in 1901, and 1.89:1 in 1906. It happens that in this particular series the amount of available nitrogen offered to the crop is greater than that in any other series, and this circumstance may serve to account for the relations noted. It will be observed that in 1901 the proportion of straw to grain in series 12 was relatively large; in 1906 it was relatively small. Evidently the more generous supply of available nitrogen, through a longer period in 1901, allowed a greater accumulation of nitrogen in the straw, whereas in 1906 the soil itself could not supply as much available nitrogen, and the nitrate nitrogen applied earlier

in the season was not sufficiently great in amount to encourage a retarded maturation of the grain, and a proportionately larger amount was, *therefore, transported from the straw to the grain.* As in 1906, the even series 8, 10, 12, 14 and 16 showed a smaller proportion of straw to grain in 1901 than did the corresponding odd series 7, 9, 11, 13 and 15. The only exception to be noted here is that in case of series 12. On the whole, these differences were not as pronounced in 1901 as they were in 1906.

The Average Per Cent. of Nitrogen in the Dry Matter, 1906.

Series.	Grain. %	Straw. %	Entire Crop. %
1	2.207	0.876	1.211
2	1.692	0.357	0.759
3	1.714	0.315	0.766
4	1.781	0.315	0.779
5	1.782	0.303	0.778
6	1.732	0.328	0.781
7	1.573	0.305	0.712
8	1.682	0.361	0.818
9	1.761	0.336	0.832
10	1.827	0.383	0.889
11	1.881	0.336	0.845
12	2.063	0.413	0.985
13	1.821	0.357	0.822
14	1.891	0.393	0.927
15	1.786	0.344	0.815
16	1.782	0.368	0.857
17	1.936	0.467	0.923
18	1.685	0.329	0.750
19	1.859	0.380	0.874
20	1.845	0.338	0.821

The Average Per Cent. of Nitrogen in the Dry Matter, 1901.

Average of Two Marked with an *.

Series.	Grain. %	Straw. %	Entire Crop. %
1	1.81*	0.39*	0.93*
2	1.75*	0.30*	0.83*
3	1.54*	0.33*	0.76*
4	1.52*	0.29*	0.71*
5	1.53*	0.24*	0.71*
6	1.59*	0.25*	0.77*
7	1.50*	0.23*	0.69*
8	1.63	0.27	0.78
9	1.55*	0.23*	0.72*
10	1.58*	0.23*	0.75*
11	1.58*	0.27*	0.73*
12	1.65	0.27	0.77
13	1.66	0.28	0.79
14	1.63*	0.26*	0.79*
15	1.55*	0.25*	0.75*
16	1.69*	0.26*	0.81*
17	1.62*	0.24*	0.77*
18	1.65*	0.24*	0.77*
19	1.64	0.26	0.79
20	1.58*	0.24*	0.73*

The abnormal proportion of nitrogen in both the grain and straw of series 1, in 1906, is quite striking. Evidently the lack of phosphoric acid prevented its proper utilization. It will be noted that the proportion of nitrogen in the straw is more than twice as great as that in the straw from all but one of the other series. We find, likewise, that the proportion of nitrogen in the grain of series 4 is greater than that in the grain of series 3. In the straw, on the other hand, the proportion of nitrogen is the same.

All of the even series, where nitrate was applied, show a greater proportion of nitrogen in their dry matter than do the corresponding odd series. This applies to the grain, as well as to the straw, as may be seen by comparing series 7 and 8, 9 and 10, 11 and 12, 13 and 14, 15 and 16, and the only exception to be noted here is that in the case of the two series last named, the grain of series 15, showing a slightly higher proportion of nitrogen than that of series 16. It appears, therefore, that under certain con-

ditions, a higher proportion of nitrogen in the grain is always accompanied by a higher proportion of nitrogen in the straw or vice versa. The solid, fresh, manure in series 3 showed a slighter proportion of nitrogen in its crop than did the solid and liquid, fresh. These relations were retained where the manures were used in combination with nitrate, as will be shown by a comparison of series 9 and 11, and of series 10 and 12.

The solid, leached, in series 5, showed a greater proportion of nitrogen in its yield of grain than did the solid and liquid, leached, in series 6. These relations, as was the case with the fresh manures, are also retained where the manure and nitrate were used in combination. Hence the higher proportion of nitrogen in the dry matter of series 13 as against that in the dry matter of series 15, and the higher proportion of nitrogen in the dry matter in series 14 as against that in the dry matter of series 16.

A further fact to be noted here is the much higher proportion of nitrogen in the dry matter of series 17, when compared with series 18. The grain in the former series contained 1.936 per cent. of nitrogen, and the straw 0.467 per cent. of nitrogen, as against the corresponding 1.685 per cent. and 0.329 per cent. in series 18. This is probably due to the accumulation of the acid residues in the soils of series 17, where ammonium sulphate has been applied annually for nine years. The physiological or bacteriological abnormalaties thus introduced have in some manner prevented the proper assimilation of whatever nitrogen was gathered by the crop in series 17. Where the ammonium sulphate was applied, together with the solid manure, leached, as in series 19, the disturbances in growth, as indicated by the proportion of nitrogen in the crop, are not as apparent. At the same time there was even here a higher proportion of nitrogen in both the grain and straw of series 19, as compared with that in the grain and straw of series 20, where the solid manure, leached, was used in combination with dried blood.

The dry matter of the wheat crop of 1901 is, on the whole, relatively poorer in nitrogen than the dry matter of the crop of 1906. This applies to both the grain and the straw. The rela-

tions brought out in 1906 are not as marked in 1901, and it may only be stated with certainty that the double portion of nitrate, whether used alone or in combination with the manures, produced, in most instances, grain with a higher proportion of nitrogen than did the corresponding single portion of nitrate. These differences were decidedly less prominent in the straws than they were in the grains. Also, here the solid and liquid, fresh, when used in combination with nitrate, yielded a dry matter with a higher proportion of nitrogen than did the solid, fresh, under the same conditions. On the other hand, where these manures were used alone, the solid, fresh, produced a dry matter with a higher proportionate content of nitrate than did the solid and liquid, fresh.

The dry matter in series 17 and 18 did not show the difference in 1901 that it showed in 1906. Evidently the differentiation in the soils had not progressed as far. Where the ammonium sulphate was used in combination with solid manure, leached, in series 19, the proportionate content of nitrogen in the dry matter was greater than that in series 20, where the same manure was used in combination with dried blood. On the whole, however, the lack of uniformity in the crop returns for 1901 makes a proper comparison difficult.

The Average Amount of Nitrogen in Crop, 1906.

Series.	Grain. gms.	Straw. gms.	Entire Crop. gms.	Proportion of Grain to Straw.
1	0.250	0.295	0.545	1:1.18
2	0.502	0.245	0.747	1:0.49
3	1.297	0.499	1.796	1:0.38
4	1.805	0.689	2.494	1:0.38
5	1.390	0.506	1.896	1:0.36
6	1.322	0.525	1.847	1:0.40
7	0.975	0.398	1.373	1:0.41
8	1.472	0.596	2.068	1:0.41
9	1.839	0.657	2.496	1:0.36
10	2.162	0.841	3.003	1:0.39
11	2.339	0.865	3.204	1:0.37
12	2.785	1.052	3.837	1:0.38
13	1.663	0.701	2.364	1:0.42
14	2.118	0.796	2.914	1:0.38
15	1.524	0.606	2.130	1:0.40
16	1.854	0.725	2.579	1:0.39
17	0.839	0.450	1.289	1:0.54
18	0.803	0.348	1.151	1:0.43
19	1.611	0.654	2.265	1:0.41
20	1.630*	0.633	2.263	1:0.39
Average	1.509	0.554	2.113	

The Average Amount of Nitrogen in Crop, 1901.

Average of Two Marked with an *.

Series.	Grain. gms.	Straw. gms.	Entire Crop. gms.	Proportion of Grain to Straw.
1	0.567*	0.198*	0.765*	1:0.35
2	0.697*	0.178*	0.875*	1:0.28
3	1.495*	0.574*	2.070*	1:0.38
4	1.523*	0.545*	2.068*	1:0.36
5	1.440*	0.390*	1.830*	1:0.27
6	1.304*	0.326*	1.630*	1:0.25
7	1.139*	0.304*	1.443*	1:0.27
8	2.014	0.548	2.562	1:0.27
9	2.042*	0.534*	2.576*	1:0.26
10	2.659*	0.624*	3.283*	1:0.23
11	2.124*	0.663*	2.787*	1:0.32
12	2.574	0.773	3.350	1:0.30
13	2.116	0.584	2.700	1:0.28
14	2.466*	0.646*	3.112*	1:0.26
15	1.965*	0.509*	2.474*	1:0.26
16	2.936*	0.725*	3.661*	1:0.25
17	1.859*	0.449*	2.309*	1:0.24
18	1.629*	0.387*	2.017*	1:0.24
19	2.465	0.620	3.085	1:0.25
20	1.902*	0.485*	2.387*	1:0.25
	1.846	0.502	2.349	

The average yields of nitrogen in the crop of 1906 confirm the relations already noted in the case of the dry matter. The average amount of nitrogen found in the grain of series 1 was actually smaller than that found in the straw. The reasons for this were already discussed in connection with the yields of dry matter. In series 2 these relations are quite different. We find here an average yield of 0.502 gms. of nitrogen in the grain as against a yield of 0.245 gms. of nitrogen in the straw, making the proportions 1:0.49, whereas in series 1, it was 1:1.18. The average yields of nitrogen in the grain and straw of series 3, where solid manure, fresh, was employed, are markedly inferior to those in series 4, where the solid and liquid portion was applied. These differences are consistently retained in the series where the manures in question were used in combination with nitrate. We find, thus, that the average yield of nitrogen in series 9 was 1.839 gms. in the grain, and 0.657 gms. in the straw, while in series 11 it was 2.339 gms. and 0.848 gms., respectively. Similarly, in series 10 and 12 where the double quantity of nitrate was applied, together with the manure, the solid and liquid portion retained its superiority. In the case of the leached manures the solid portion gave higher returns of nitrogen than did the solid and liquid portion where these materials were used alone. Where used in combination with 5 or 10 gms. of sodium nitrate the same relations appear very distinctly, as will be demonstrated by the comparison of the yields in series 13 and 15, and series 14 and 16.

The double portion of nitrate shows consistent superiority over the single portion either when used alone or in combination with any of the manures. Series 7 where 5 gms. of nitrate were applied on each soil gave an average return in the crop of 0.975 gms. of nitrogen for the grain, and of 0.398 gms. of nitrogen for the straw. In series 8, the corresponding figures were 1.469 gms. and 0.596 gms., the proportions in grain and straw remaining the same. In the same manner series 10 proved superior to series 9; series 12 superior to series 11; series 14 superior to series 13, and series 16 superior to series 15. The proportion of nitrogen in the grain to that in the straw was greater in the

yield from the single portion of nitrate when it was used in combination with either of the fresh manures. When used with either of the leached manures, the proportion of nitrogen in the grain to that in the straw was greater in the yield from the double portion of nitrate.

Comparing the yields of nitrogen in series 17 and 18, where ammonium sulphate and dried blood, respectively, were used, we observe larger returns from the former, both in the straw and in the grain. Moreover, the proportion of the nitrogen in the grain to that in the straw is smaller in 17 than it is in 18. These differences are likewise manifested, though to a slighter extent, in series 19 and 20, where these materials were used in combination with solid manure, leached.

The modifications which the cylinder soils have undergone from the first to the second rotation are clearly indicated in the relation of the wheat crop of 1901 to that of 1906. It will be observed that the total yield of nitrogen in series 1 was 0.765 gms. in 1901, and 0.545 gms. in 1906. The reduction is due to the diminished yield of nitrogen in the grain of 1906, while the nitrogen in the straw was actually greater in 1906 than it was in 1901. We note, likewise, a reduction in the total yield of nitrogen in the other series with the exception of 4, 5, 6, 11 and 12. A further examination of the data will show that the nitrogen yields in the grain alone show a reduction in all but four of the series, namely, 4, 6, 11 and 12. On the other hand, the nitrogen yields in the straw alone show a gain in all but three of the series, namely, 3, 16 and 18. Taking the average of all the yields, we find an average return in 1901 of 1.876 gms. nitrogen for the grain, 0.502 gms. nitrogen for the straw, and 2.349 gms. nitrogen for the entire crop. In 1906 the corresponding returns were 1.509 gms., 0.553 gms. and 2.112 gms. of nitrogen, respectively. There was thus a reduction in the total average yield of nitrogen of a little more than 10 per cent. This reduction represents an actual decrease in the crop-producing power of the soil, since there is no reason to suppose that the season of 1906 was less favorable for the growth of wheat than was the season of 1901. It is quite instructive to note that the series which show a

gain in the yield of nitrogen are the manure series 4, 5, 6 and likewise 11 and 12, where the solid and liquid, fresh, was used in combination with nitrate. On the other hand, series 7 and 8, where no organic materials were used, showed a distinct reduction in yield. This is even more striking in the case of series 17 and 18 which have been receiving applications of ammonium sulphate and dried blood, respectively. This notable falling off in yield is undoubtedly due to the increasing acidity of the soil in these series, the reduction having been greatest in the case of series 17 and 19, where ammonium sulphate was used alone, or in combination with solid manure, leached. In series 18 and 20, where dried blood was used instead of ammonium sulphate, the reduction, for reasons quite evident, was not as great. We thus find that in series 17 there was a reduction in yield from 1901 to 1906, of somewhat more than 44 per cent. The corresponding decrease in series 18 was not quite 43 per cent. The presence of solid manure, leached, in series 19 led to an improvement in the returns from the nitrogen applied. The reduction in yield from 1901 to 1906 was 26.6 per cent. in series 19, and only 5.2 per cent. in series 20. If, therefore, the falling off in yield from the first to the second rotation was due in series 17 and 18 to the accumulation of acid residues, the presence of the leached manure counterbalanced, to a great extent, the injurious influence of these residues which were quantitatively slighter in series 18 than they were in series 17.

Average Increase Over the Check Plot, and the Average Per Cent. of Nitrogen Recovered, 1906.

Series.	Increase in Yield of Nitrogen.	Nitrogen Recovered.	Calculated Recovery.	Nitrogen not Recovered.
1	......	......	......	.....
2	......	......	......	.....
3	1.049	25.9	......	.....
4	1.747	43.6	......	.....
5	1.149	28.4	......	.....
6	0.849*	21.0	......	.....
7	0.626	80.3	......	.....
8	1.321	85.2	......	.....
9	1.749	36.2	34.7	.....
10	2.256	40.3	42.3	2.0
11	2.457	51.3	49.5	.....
12	2.683*	48.3	55.1	6.8
13	1.617	33.5	36.7	3.2
14	2.167	38.7	44.1	5.4
15	1.383	28.7	30.7	2.0
16	1.832	32.8	38.8	6.0
17	0.542	33.5	......	.....
18	0.404	25.7	......	.....
19	1.518	26.8	29.8	3.0
20	1.516	27.0	27.6	0.6

Average Increase Over the Check Plot, and the Average Per Cent. of Nitrogen Recovered, 1901.

Series.	Increase in the Yield of Nitrogen. Average of Three.	Increase in the Yield of Nitrogen. Proximate Average.	Nitrogen Recovered. Average of Three.	Nitrogen Recovered. Proximate Average.	Calculated Recovery.	Nitrogen not Recovered.
1	......	......	......	......	......	.....
2	......	......	......	......	......	.....
3	1.177	1.195	33.3	30.2	......	.....
4	1.218	1.193	34.0	29 9	......	.....
5	1.082	0.955	30.3	23.7	......	.....
6	0.895	0.755	26.6	19.4	......	.....
7	0.727	0.672	110.9	86.2	......	.....
8	1.548	1.687	108.9	97.2	......	.....
9	1.791	1.701	40.7	40.7	39.4	.....
10	2.670	2.408	51.0	51.0	49.1	.....
11	2.230	1.912	49.6	40.1	39.1	.....
12	2.336	2.475	44.7	44.7	48.7	4.0
13	1.686	1.825	38.0	38.0	33.9	.....
14	2.285	2.237	43.5	43.5	44.1	0.6
15	1.284	1.599	30.5	30.5	30.6	.....
16	2.314	2.786	39.0	39.0	41.3	2.3
17	1.120	1.434	77.7	88.5	......	.....
18	1.279	1.142	91.4	73.6	......	.....
19	2.071	2.210	39.1	39.1	39.2	.....
20	1.299	1.512	25.9	25.9	37.6	11.7

* Average of two.

It was already stated in the preceding pages that the yields of dry matter and of nitrogen in the wheat crop of 1901 were not uniform, and hence in the making up of the averages for each series some of the abnormally high or abnormally low yields were eliminated. The data thus secured were tabulated under the heading of "Proximate Average" to distinguish them from those secured by averaging all three of the yields in each series. The greater uniformity of the results in 1906 allowed the averaging of the three yields in each series.

Because of the larger crop yields in 1901 on the check series 2, the amount subtracted from the average yield in each series was greater. Comparing the amounts of nitrogen due to the different nitrogenous materials added, we find that in 7 out of 18 series the increase over the check plot was greater in 1906 than it was in 1901 (the average of three being taken in 1901). Thus the increase in the yields in series 4, 5, 6, 11, 12, 15 and 20, was 1.747 gms., 1.149 gms., 1.100 gms., 2.440 gms., 3.090 gms., 1.383 gms. and 1.516 gms., respectively, in 1906; and 1.218 gms., 1.082 gms., 0.895 gms., 2.230 gms., 2.336 gms., 1.284 gms., and 1.299 gms., respectively, in 1901. The increase occurs, therefore, in the series where the solid and liquid manure, fresh, was used alone (series 4), or in combination with nitrate (series 11 and 12). It occurs, likewise, in the series where the solid manure, leached, was used alone (series 5), or in combination with dried blood (series 20). It occurs also in the series where the solid and liquid manure, leached, was used alone (series 6), or in combination with 5 gms. of nitrate (series 15).

In comparing the average recoveries for the two seasons, we observe that the nitrate, ammonium sulphate, and dried blood, where used alone, showed a falling off in the second rotation. The proximate average recovery was 86.2 per cent. and 97.2 per cent. for series 7 and 8, respectively, in 1901; the corresponding returns in 1906 being 82.0 per cent. and 85.2 per cent. It appears, therefore, that the reduction was greater in series 8 where the double quantity of nitrate was used. In the case of the ammonium sulphate and dried blood the falling off in yield from the first to the second rotation was quite striking. The first of

these showed a falling off from a proximate average of 88.5 per cent. to 33.5 per cent., and the latter, a falling off from a proximate average of 73.6 per cent. to 25.7 per cent. These reductions in yield are chiefly due to two causes. In the first place, the continuous cropping of the soils under experiment with heavy annual applications of acid phosphate and muriate of potash, and slight (dried blood) or no additions of organic matter, besides that supplied in the roots and stubble, must necessarily lead to a reduction of the humus content of the soil. This reduction involves the deterioration of the soil in its physical and bacteriological relations, and hence a decreased crop-producing power. In the second place, the soils receiving ammonium sulphate and dried blood tend to become distinctly acid in the course of time. This is particularly true of those receiving ammonium sulphate. It will be remembered that a certain amount of lime, or of other bases, is used up in the nitrification of the ammonia. A further amount is needed for the neutralization of the residual sulphuric acid. Moreover, since the basic portion of the ammonium sulphate is used by the crops to a greater extent than is the acid portion, there must be a gradual increase in the content of acid salts in the soils. In the case of dried blood the conditions making for an accumulation of soil acidity are by no means as prominent. On the other hand, the soils where sodium nitrate is applied year after year would tend to become more alkaline in the course of time. In this case it is the acid radical which is utilized in greater proportion, whereas the basic radical not being used by the crops to the same extent increases in quantity in the soil. This accumulation of sodium carbonate or bicarbonate in the soil leads to certain modifications in its physical properties, which are well known in districts where large quantities of sodium nitrate are used. On heavy clay soils the changes thus introduced may become quite objectionable, involving as they do the deflocculation of the compound grains and the puddling of the surface soil. Hence in comparing the yield on the several cylinder soils proper allowance should be made for the new factors introduced in each case by a definite system of soil treatment whose effect is of necessity cumulative.

The recoveries from the manures where these were used alone or in combination with nitrate also show interesting relations. It will be noted that in 1906, the solid manure, fresh, showed a recovery of 25.9 per cent., and the solid and liquid, fresh, a recovery of 43.6 per cent. The superiority of the latter was maintained also in the combinations, since the recoveries in series 11 and 12 were 51.3 per cent. and 48.2 per cent., respectively, in series 9 and 10. Again, the solid, leached, showed a recovery of 28.3 per cent. and the solid and liquid, leached, a recovery of 21.0 per cent. When used in combination with nitrate these materials showed a recovery of 33.5 per cent. and 38.7 per cent. in series 13 and 14; and a recovery of 28.7 per cent. and 32.8 per cent. in series 15 and 16, thus again maintaining the superiority of the solid, leached, over the solid and liquid, leached. A further fact to be noted here is the higher recovery from the 10 gms. of nitrate as compared with that from the 5 gms. of nitrate. With one exception this relation was also maintained in the series where the nitrate was used in combination with manure. Thus the recovery in series 9 was 36.2 per cent. and in series 10, 40.3 per cent. The recovery in series 13 was 33.5 per cent. and in series 14, 38.7 per cent. The recovery in series 15 was 28.7 per cent., and in series 16, 32.8 per cent. The same relations appear also in the crop of 1901, where the recovery in series 9 was 40.7 per cent., and in series 12, 44.7 per cent. The recovery in series 13 was 38.0 per cent., and in series 14, 43.5 per cent. The recovery in series 15 was 30.5 per cent., and in series 16, 34.0 per cent.

Theoretically, the increase in yield over the check plot, due to the application of any of the nitrogenous materials should be secured also in the series where these materials are used in combination. If a certain increase is due to the application of 5 gms. of nitrate in one series and a definite increase, due likewise to the application of manure, in another series, the total increase secured from using the two in combination in a third series, should equal the sum of the first two quantities. The amounts thus recoverable can be readily calculated, and the difference between the per cent. of nitrogen actually recovered and the

per. cent. recoverable represents the losses due to all causes. Such losses may be due to the less perfect utilization of the materials applied in combination or they may be due to denitrification. It will be noted that a small proportion of nitrogen was not recovered in series 10, 12, 13, 14, 15, 16, 19 and 20. It will be noted, also, that the greatest proportion not recovered occurs in series 12, 14 and 16, where 10 gms. of nitrate were used in combination with manure. The amounts not recovered where only 5 gms. of nitrate were used in combination with the corresponding manures would indicate that in the season of 1906 there was a slight but appreciable amount of denitrification. In view of the fact that the manures are applied annually in the cylinder soils, and in rather large quantities, the danger from denitrification under actual field conditions cannot be very great, as has been noted in previous reports.

The Availability of the Different Nitrogenous Materials When That of the Nitrate is Taken as 100.

	Wheat, 1901.	Wheat, 1906.
Sodium Nitrate	100.0	100.0
Ammonium Sulphate	91.0	39 3
Dried Blood	75.7	30.2
Solid Manure, Fresh	31.1	30.4*
Solid and Liquid, Fresh	30.8	51 2
Solid, Leached	24.4	33 3
Solid and Liquid, Leached	19.9	24 6

It may be seen at a glance, from the above tabulation, that there has been a striking reduction in the availability of the ammonium sulphate and dried blood nitrogen since 1901. The manures, on the other hand, show in three cases out of four a higher availability in 1906. This is particularly marked in the case of the solid and liquid, fresh, which showed an availability of 51.2 in 1906, as against 30.8 in 1901. The higher availability of the animal manures in 1906 may be due, on the one hand, to the abundant rainfall of that year, and, on the other, to the cumulative effect of the annual dressings of manure. Be it as it may, the 4 gms. of nitrogen applied in these materials are not apparently utilized beyond a certain point, and that notwithstanding the repeated applications for a period of nine years.

PLANT NUTRITION STUDIES.

BY EDWARD B. VOORHEES AND JACOB G. LIPMAN.

The following is a report of progress of experiments begun in 1905.[1] It was intended to determine, with the aid of these experiments, what the fertilizer requirements of certain well-defined soil types may be, and to use the information thus secured for working out specific recommendations for a scheme of soil treatment. The description of the experiment plant, and likewise a statement as to the origin and history of the soils employed, will be found in the report just referred to. For the convenience of the reader the following brief description is appended:

Pot Experiments.

To study the growth of leguminous plants upon the poor, medium and good soils of the red shale (Penn loam) type.

Lines of Study.

1. The effect of an abundance of phosphoric acid.
2. " " " " " " potash.
3. " " " small, medium and large amounts of potash (KCl), in the presence of an abundance of available phosphoric acid (superphosphate).
4. The effect of small, medium and large amounts of phosphoric acid (superphosphate), in the presence of an abundance of potash (KCl).

Plan of Experiment.

1. Poor soil. Taken from the land of Charles Howell Cook, Belle Mead, N. J.
2. Medium soil.
3. Good soil.

[1] See N. J. Stat. Rep., 1905, p. 211.

LIBRARY
TNAU, Coimbatore - 3

Number of Pots and Treatment.

Weight of Soil in Pots—Twenty Pounds.

Series I. (Two pots in each series.)	Phosphoric Acid. gms.	Potash. gms.	1905. Yield in Grams.		Av.	1096. Yield in Grams.		Av.	Sum of Averages.	Increase due to materials applied.
Poor Soil.										
1a, 1b	.....	.....	1a, 28	1b, 32	30	1a, 8	1b, 22	15	45	...
2a, 2b	2.00	.....	2a, 44	2b, 42	43	2a, 43	2b, 41	42	85	40
3a, 3b	.....	1.00	3a, 28	3b, 33	30	3a, 24	3b, 21	22	52	7
4a, 4b	2.00	0.25	4a, 44	4b, 43	43	4a, 41	4b, 36	38	81	36
5a, 5b	2.00	0.50	5a, 44	5b, 42	43	5a, 39	5b, 37	38	81	36
6a, 6b	2.00	1.00	6a, 43	6b, 42	42	6a, 45	6b, 38	41	83	38
7a, 7b	0.50	1.00	7a, 39	7b, 36	37	7a, 29	7b, 25	27	64	19
8a, 8b	1.00	1.00	8a, 44	8b, 35	39	8a, 32	8b, 32	32	71	26
*9a, 9b	2.00	1.00	9a, 33	9b, 29	31	9a, 48	9b, 43	45	76	21
Medium Soil.										
10a, 10b	.....	.....	10a, 44	10b, 48	46	10a, 41	10b, 45	43	89	...
11a, 11b	2.00	.....	11a, 38	11b, 45	41	11a, 8	11b, 32	20	61	...
12a, 12b	.....	1.00	12a, 48	12b, 49	48	12a, 45	12b, 39	42	90	...
13a, 13b	*2.00*	*0.25*	*13a, 49*	*13b, 48*	48	*13a, 49*	*13b, 54*	*51*	99	*10*
14a, 14b	2.00	0.50	14a, 56	14b, 46	51	14a, 47	14b, 36	44	95	6
15a, 15b	2.00	1.00	15a, 52	15b, 46	49	15a, 54	15b, 66	60	109	19
16a, 16b	0.50	1.00	16a, 51	16b, 43	47	16a, 41	16b, 43	42	89	...
17a, 17b	*1.00*	*1.00*	*17a, 57*	*17b, 45*	*51*	*17a, 52*	*17b, 32*	*42*	*83*	...
*18a, 18b	2.00	1.00	18a, 57	18b, 51	54	18a, 54	18b, 48	51	105	16
Good Soil.										
19a, 19b	.....	.....	19a, 37	19b, 35	36	19a, 37	19b, 24	30	66	...
20a, 20b	2.00	.....	20a, 48	20b, 40	44	20a, 47	20b, 42	44	88	22
21a, 21b	.....	1.00	21a, 41	21b, 36	38	21a, 33	21b, 36	34	72	6
22a, 22b	2.00	0.25	22a, 49	22b, 43	46	22a, 43	22b, 44	43	89	23
23a, 23b	2.00	0.50	23a, 52	23b, 45	48	23a, 46	23b, 44	45	93	27
24a, 24b	2.00	1.00	24a, 48	24b, 44	46	24a, 46	24b, 50	48	94	28
25a, 25b	0.50	1.00	25a, 43	25b, 41	42	25a, 47	25b, 35	41	83	17
26a, 26b	1.00	1.00	26a, 41	26b, 40	40	26a, 49	26b, 36	42	82	16
*27a, 27b	2.00	1.00	27a, 30	27b, 39	34	27a, 42	27b, 43	42	76	10
†58a, 58b, Poor soil	2.00	0.75	58a, 12	58b, 11	11	58a, 26	58b, 28	27	37	...
†59a, 59b, Medium soil	2.00	0.75	59a, 11	59b, 12	11	59a, 36	59b, 26	31	42	...
†60a, 60b, Good soil	2.00	0.75	60a, 17	60b, 15	16	60a, 25	60b, 28	26	42	...

* No lime applied.

† Oats and cow peas together in 1905, spring wheat and cow peas together in 1906.

The applications of acid phosphate, of potassium chloride, and of lime, were made in 1905, as indicated above. After the cow peas were harvested in the fall of 1905, the soils were allowed to dry out, and were stored in this condition until the following spring, when they were again moistened, thoroughly mixed, and cow peas seeded again without further application of fertilizers.

It will be seen that on the poor soil the effect of the phosphoric acid was quite marked. In series 2 the yield of dry matter was almost double that in series 1. In series 4, 5 and 6, where 2 gms. of acid phosphate were used with varying quantities of potash, there was a similar increase. In series 7, 8 and 9, where .50, 1.00 and 2.00 gms., respectively, of acid phosphate were used together with 1.00 gm. of potassium chloride, there was a gradual increase in the yield with the increasing amount of phosphoric acid supplied. Series 9 was treated like series 6, but received no lime, hence the yield here was only 21 gms., as against 38 gms. in series 6. It should also be noted here that there was a considerable falling off in yield from 1905 to 1906, except in the series where the large quantities of phosphoric acid were applied.

In the case of the medium soil the results are not as conclusive. Both in 1905 and 1906 the yields in series 11 were, for some reason, actually smaller than those in series 10, where neither acid phosphate nor potassium chloride were employed. In series 13, 14 and 15, where the full quantity of phosphoric acid was used, a slight gain is indicated, as it is also in series 18, even though the soils of the latter received no lime.

Again, in the good soil, the favorable influence of phosphoric acid is almost as marked as it is in the poor soil. Thus in series 20, 22, 23 and 24 there was an increase in the yield of dry matter ranging from 22 to 28 gms. With the gradually increasing quantities of phosphoric acid, in series 25, 26 and 24, there is also an appreciable gain in dry matter, although the yield in series 26 is smaller than it should have been. In series 27, where no lime was applied, the full quantity of phosphoric acid and potash failed to produce the increase secured in the corresponding limed series 24. Finally, series 58, 59 and 60, representing, respectively, the poor, medium and good soil, and used for the growing together of cow peas and oats in 1905, and of cow peas and spring wheat in 1906, yielded more dry matter in the cow peas of 1906 than they furnished in the cow pea crop of 1905. The greater yield of 1906 will be explained partly by the failure of the spring wheat, which was badly affected by rust.

On the whole, therefore, the cow pea crops of the two seasons demonstrated that phosphoric acid is the controlling plant-food constituent for legumes on the red shale soils; that the effect of acid phosphate is better felt in the presence of lime, and that without further application of fertilizers in the second season, the yield was best maintained in the soils where the larger quantity of phosphoric acid had been applied.

Pot Experiments.

To study the soils of the red shale (Penn loam) formation in respect to their need for constituent plant-food elements, namely, nitrogen, phosphoric acid and potash, in the growth of cereals.

Lines of Study.

1. The effect of phosphoric acid (superphosphate) alone.
2. " " " potash (KCl) alone.
3. " " " nitrogen as nitrate when used with phosphoric acid or potash.
4. The effect of the mineral elements, phosphoric acid and potash, alone.
5. " " " nitrogen as nitrate, as ammonia, and as organic matter, in combination with minerals.

Plan of Experiment.

1. Poor soil. Taken from the farm of Charles Howell Cook, Belle Mead, N. J.
2. Medium soil.
3. Good soil.

Number of Pots and Treatment.

Poor Soil.

Series II. (Two pots in each series.)		gms.	1905. Yield in Grams.		Av.	1906. Yield in Grams.		Av.
28a, 28b,	Nothing	......	28a, 17	28b, 18	17	28a, 9	28b, 9	9
29a, 29b,	Phosphoric acid	2.00	29a, 23	29b, 21	22	29a, 8	29b, 9	8
30a, 30b,	Potash	0.75	30a, 18	30b, 16	17	30a, 8	30b, 8	8
31a, 31b,	Phosphoric acid Nitrogen, as nitrate	2.00 1.00	31a, 31	31b, 29	30	31a, 7	31b, 7	7
32a, 32b,	Potash Nitrogen, as nitrate	0.75 1.00	32a, 21	32b, 16	18	32a, 7	32b, 7	7
33a, 33b,	Phosphoric acid Potash	2.00 0.75	33a, 22	33b, 23	22	33a, 8	33b, 10	9
34a, 34b,	Phosphoric acid Potash Nitrogen, as nitrate	2.00 0.75 1.00	34a, 36	34b, 30	33	34a, 8	34b, 8	8
35a, 35b,	Phosphoric acid Potash Nitrogen, as sulphate of ammonia	2.00 0.75 0.76	35a, 28	35b, 29	28	35a, 8	35b, 8	8
36a, 36b,	Phosphoric acid Potash Nitrogen, as dried blood	2.00 0.75 1.18	36a, 29	36b, 28	28	36a, 9	36b, 7	8

Medium Soil.

Series II. (Two pots in each series.)		gms.	1905. Yield in Grams.		Av.	1906. Yield in Grams.		Av.
37a, 37b,	Nothing	......	37a, 18	37b, 17	17	37a, 5	37b, 4	4
38a, 38b,	Phosphoric acid	2.00	38a, 24	38b, 26	25	38a, 5	38b, 5	5
39a, 39b,	Potash	0.75	39a, 22	39b, 24	23	39a, 5	39b, 6	5
40a, 40b,	Phosphoric acid Nitrogen, as nitrate	2.00 1.00	40a, 32	40b, 32	32	40a, 5	40b, 5	5
41a, 41b,	Potash Nitrogen, as nitrate	0.75 1.00	41a, 26	41b, 27	26	41a, 5	41b, 6	5
42a, 42b,	Phosphoric acid Potash	2.00 0.75	42a, 30	42b, 26	28	42a, 6	42b, 6	6
43a, 43b,	Phosphoric acid Potash Nitrogen, as nitrate	2.00 0.75 1.00	43a, 30	43b, 30	30	43a, 6	43b, 6	6
44a, 44b,	Phosphoric acid Potash Nitrogen, as sulphate of ammonia	2.00 0.75 0.76	44a, 34	44b, 29	31	44a, 6	44b, 5	5
45a, 45b,	Phosphoric acid Potash Nitrogen, as dried blood	2.00 0.75 1.18	45a, 30	45b, 29	29	45a, 5	45b, 5	5

Good Soil.

Series B. (Two pots in each series.)		gms.	1905. Yield in Grams.				Av.	1906. Yield in Grams.				Av.
46a, 46b.	Nothing	.....	46a,	20	46b,	21	20	46a,	5	46b,	7	[illegible]
47a, 47b.	Phosphoric acid	2.00	47a,	24	47b,	25	24	47a,	7	47b,	7	7
48a, 48b.	Potash	0.75	48a,	21	48b,	20	20	48a,	6	48b,	5	[illegible]
49a, 49b.	Phosphoric acid *Nitrogen, as nitrate*	2.00 1.00	49a,	30	49b,	30	30	49a,	5	49b,	5	[illegible]
50a, 50b.	Potash Nitrogen, as nitrate	0.75 1.00	50a,	21	50b,	15	18	50a,	8	50b,	6	[illegible]
51a, 51b.	Phosphoric acid Potash	2.00 0.75	51a,	21	51b,	25	23	51a,	6	51b,	7	[illegible]
52a, 52b.	*Phosphoric acid* Potash Nitrogen, as nitrate	2.00 0.75 1.00	52a,	28	52b,	25	26	52a,	7	52b,	6	[illegible]
53a, 53b.	Phosphoric acid Potash Nitrogen, as sulphate of ammonia	2.00 0.75 0.76	53a,	28	53b,	28	28	53a,	7	53b,	6	[illegible]
54a, 54b.	*Phosphoric acid* Potash Nitrogen, as dried blood	2.00 0.75 1.18	54a,	29	54b,	25	27	54a,	8	54b,	10	[illegible]
55a, 55b.	*Poor soil. Nitrate of soda*	1.00	55a,	18	55b,	17	17	55a,	8	55b,	7	[illegible]
56a, 56b.	Medium soil. " " "	1.00	56a,	24	56b,	22	23	56a,	4	56b,	7	[illegible]
57a, 57b.	Good soil. " " "	1.00	57a,	23	57b,	22	22	57a,	6	57b,	6	[illegible]
*58a, 58b.	*Poor soil. Phosphoric acid* Potash	2.00 0.75	58a,	15	58b,	18	16	58a,	5	58b,	7	[illegible]
*59a, 59b.	Medium soil. Phosphoric acid Potash	2.00 0.75	59a,	17	59b,	18	17	59a,	3	59b,	4	[illegible]
*60a, 60b.	Good soil. Phosphoric acid Potash	2.00 0.75	60a,	16	60b,	17	16	60a,	6	60b,	6	[illegible]

The spring wheat of 1906 was so badly rusted as to preclud[illegible] in the yields an expression of the fertility conditions of the di[illegible]ferent soils. The weights of the dry matter secured are inserte[illegible] here as a matter of record.

Going back to the yields of 1905, we find the following averag[illegible] increase over the nothing series, as due to the materials applied[illegible]

Increase Over the Nothing Series.

	Poor soil.	Medium soil.	Good soil.	Average.
P_2O_5	5	8	4	6
K_2O	...	6	...	2
P_2O_5, N (nitrate)	13	15	10	13
K_2O, N (nitrate)	1	9	—2	3
P_2O_5, K_2O	5	11	3	6
P_2O_5, K_2O, N (nitrate)	16	13	6	12
P_2O_5, K_2O, N (ammonium sulphate)	11	14	8	11
P_2O_5, K_2O, N (dried blood)	11	12	7	10

The above figures show that the application of phosphoric acid esulted in an increased yield in each of the soils. The applica-on of potash alone gave an increase only in the medium soil. 'he addition of nitrogen to the phosphoric acid led to a further ery marked increase, whereas the addition of nitrogen to potash ed to a very slight further increase, and in one instance, that of he *good soil, it actually led to a reduction in the yield of dry matter.* 'he addition of potash to the phosphoric acid gave no further ncrease in the poor and good soils, but increased the yield in the nedium soil. The addition of potash to the phosphoric acid and itrogen resulted in a decrease in two out of the three soils. Where nitrate, ammonia and organic nitrogen were added to he phosphoric acid and potash, the greatest increase was pro-uced by the first named, with ammonia and organic nitrogen ollowing in the same order.

It may be concluded, therefore, that the red shale soils are in reater need of phosphoric acid than they are of nitrogen and otash. The harvests on these soils may be materially increased n the case of non-legumes, by the addition of phosphates, and to *much greater extent by the application of phosphates and* itrogen together. The application of potash will probably prove f some advantage only after an abundance of phosphoric acid nd nitrogen had been supplied

Field Experiments at Hammonton.

The present report contains a record of the crops grown, and of the yields secured on the experiment plots at Hammonton, since the beginning of these experiments in 1904. The experiment area of two acres is divided into two equal portions; the first of which consists of one-fifth acre plots, devoted to the study of soil and forage crops; the second consists of one-tenth acre plots, devoted to the study of soil improvement problems.[1]

The Soiling and Forage Crops Experiment.

The Crops Grown. Date of Seeding.

	Spring, 1904.	Fall, 1904.	Spring, 1905.	Fall, 1905.	Spring, 1906.
Plot 1..	Corn.	Crimson Clover.	Soy Beans.	Wheat and Vetch.	Corn
" 2..	Cow Peas.	Rye and Sand Vetch.	Corn.	Crimson Clover.	Millet.
" 3..	Soy Beans.	Red Clover.	Millet.	Wheat.	Cow Peas.
" 4..	Millet.	Wheat.	Cow Peas.	Rye and Vetch.	Spring Vetch.
" 5..	Mangels.	Rye.	Vetch and Oats.	Crimson Clover.	Soy Beans.

Fertilizers Applied.

Per plot. 1904.	1905.	1906.
200 lbs. lime.	32 lbs. acid phosphate.	32 lbs. acid phosphate.
64 lbs. acid phosphate.	20 lbs. muriate of potash.	20 lbs. muriate of potash.
20 lbs. ground bone.		
32 lbs. muriate of potash.		
30 lbs. dried blood.		
40 lbs. commercial fertilizer.		

Additional Applications.

	1904.	1905.	1906.
Plot 1	16 lbs. nitrate of soda.	....	15 lbs. dried blood.
" 2	....	15 lbs. dried blood.	15 lbs. dried blood.
" 3	....	15 lbs. dried blood.	....
" 4	16 lbs. nitrate of soda.	....	....
" 5	16 lbs. nitrate of soda.	....	....

[1] See N. J. Sta. Reports, 1904, p. 229; 1905, p. 218.

Yield and Value of Crops in 1905.

Date of Harvesting.	First Crop.	Per Plot. lbs.	Per Acre. lbs.		
Plot 1. May 20.	Crimson Clover Hay	470	2,350		
" 2 May 13	Rye and Vetch.	700	3,500		
" 3. June 24	Red Clover Hay	600	3,000		
" 4. May 27.	Wheat	670	3,350		
" 5.	Rye	....	.....		
	Second Crop.			**Two Crops. Total lbs.**	**Two Crops. Value.**
Plot 1. Aug. 4	Soy Beans	610	3,050	5,400	$43 20
" 2. Aug. 17	Corn	4,110	20,550	8 640	77 10
" 3. Aug. 30	Millet	940	4,700	7,700	61 60
" 4. Aug. 25	Cow Peas.	530	2,650	6,000	48 00
" 5. July 14	Oats and Vetch	528	2,640	2,640	21 12

Yield and Value of Crops, 1906.

Date of Harvesting.	First Crop.	Yield per Plot. lbs.	Yield per Acre. lbs.		
Plot 1. May 22	Wheat and Vetch	680	3,400		
" 2. June 4	Crimson Clover	680	3,400		
" 3. May 22	Wheat	950	4,750		
" 4. May 6	Rye and Vetch.	500	2,500		
" 5. June 4	Crimson Clover	730	3,650		
	Second Crop.			**Two Crops. Total lbs.**	**Two Crops. Value.**
Plot 1. Oct. 15	Corn.	1,285	6,425	9,825	$78 59
" 2. Aug. 8	Millet	1,500	7,500	10,900	87 20
" 3. Sept. 10	Cow Peas	1,125	5,625	10,375	82 99
" 4. Aug. 22	Vetch (plowed under).	......	.	2,500	20 00
" 5. Sept 24	Soy Beans	975	4 875	8,525	68 20

A comparison of the above yields of air-dry matter[1] will show at once a most gratifying improvement in the crop-producing power of the soils under experiment. Thus the yield of crimson clover hay was at the rate of 2,350 pounds per acre in 1905 (plot 1), while in 1906 it was at the rate of 3,400 pounds on plot 2, and at the rate of 3,650 pounds per acre on plot 5. The yield of wheat was at the rate of 3,000 pounds per acre (plot 4) in 1905, and at the rate of 4,750 pounds per acre (plot 3) in 1906. The yield of rye and vetch in 1906 was smaller than the corre-

[1] The corn on plot 2, in 1905, was weighed green.

sponding yield of 1905, largely on account of the failure of the vetch.

The yields of the second crops of the two seasons show even more clearly a decided improvement in the soils. We find, thus, that the soy beans of 1905 yielded at the rate of 3,050 pounds per acre (plot 1), whereas the same crop of 1906 yielded at the rate of 4,875 pounds per acre (plot 5). The yield of millet in 1905 was at the rate of 4,700 pounds per acre (plot 3), while that of 1906 was 7,500 pounds per acre (plot 2). The yield of cow peas in 1905 was at the rate of 2,650 pounds per acre (plot 4), while in 1906 it was at the rate of 5,625 pounds per acre. While the seasonal conditions of 1906 were undoubtedly more favorable for the production of maximum crops, the fact still remains that the experimental soils have been improved very markedly. Their content of humus, and of nitrogen, phosphoric acid and potash, has been increased, and the greater portion of the nitrogen, the most expensive of the fertilizer ingredients, has been secured from atmospheric sources at a comparatively slight expense.

This experiment proves convincingly that it is possible and practicable to grow forage crops for the dairy on the light sandy soils of South Jersey; that two crops may be easily harvested each season; that the purchase of organic matter for maintaining the soil humus is not necessary; that the purchase of nitrogen may be largely dispensed with; that this method assures the accumulation of organic matter in the soil and an improvement in its physical properties; that it assures the accumulation of nitrogen, phosphoric acid and potash in the soil. It may be especially noted in this connection that the gratifying results secured are due in great part to the large proportion of leguminous crops grown. Indeed, the cow peas and crimson clover, which grow so splendidly on this type of soil, have shown very marked improvements. According to Col. Richards, the growth of crimson clover on the experiment plots in 1906 was absolutely the finest he had ever seen in New Jersey or Pennsylvania. The improvement in the growth of the soy beans is fully as instructive. The crop of 1904 was practically a failure. The plants were small and yellow, and devoid of tubercles. The crop of

1906 was quite remarkable, having produced at the rate of more than two tons of soy bean hay per acre. It is quite possible that this striking increase was due, apart from the favorable climatic conditions, to the inoculation of the soil with soil from the fields of the De Hirsh Agricultural School, at Woodbine, where soy beans have been grown successfully for a number of years.

The following table shows the cost, for the three seasons, of the fertilizer materials used, and the value of the crops secured. For convenience of calculation, the uniform price of $16 per ton of dry forage is allowed in each case. This price is hardly too high, particularly in South Jersey, where the supply of succulent and nutritious food for dairy cattle is not abundant. The predominance of legumes among the crops grown on the experiment plots assures a large supply of the expensive protein substances. It will be observed, also, that the crops came in such succession as to provide a continuous supply of green forage from early May until September, and the yields show that one acre, on this basis, would provide a sufficient amount of roughage for one cow for one year, supplying it in the form of dry hay at the rate of sixteen and two-thirds pounds per day.

In view of the facts herein reported, it is not at all unreasonable to assume that thousands of acres of sandy soil in the counties of Atlantic, Cape May, Cumberland and Ocean, now uncultivated and unproductive, may under proper conditions be utilized for dairy purposes to supply local needs, and to furnish, besides, a supply of dairy products for the large centres of population more or less distant. This is particularly true of the important summer resorts, like Atlantic City, Ocean City, Sea Isle City, Wildwood, &c. Under the existing conditions, the quality and quantity of these products supplied at these resorts have much to be desired, and the complaint is frequently heard as to the inadequacy of good, wholesome milk in these places for young children. There is much encouragement, therefore, in the heavy yields of forage secured on the experiment plots at Hammonton; and it is hoped that the lessons to be deduced from these experiments may find practical application on the light soils of South Jersey, for the much-needed development, in certain sections, of modern dairy establishments.

Cost of Fertilizers and Value of Crops for Three Years.

	1904.		1905.		1906.				
	Cost of Fertilizers per acre.	Value of Crops per Acre.	Cost of Fertilizers per Acre.	Value of Crops per Acre.	Cost of Fertilizers per Acre.	Value of Crops per Acre.	Total Cost per Acre.	Total Value per Acre.	Gain per Acre.
Plot 1	$13 52	$17 20	$2 80	$43 20	$4 11	$78 59	$20 43	$138 99	$118 5
" 2	11 92	15 20	4 11	77 10	4 11	87 20	20 14	179 50	159 3
" 3	11 92	....	4 11	61 60	2 80	82 99	18 83	144 59	125 7
" 4	13 52	23 00	2 80	48 00	2 80	20 00	19 12	91 00	71 8
" 5	13 52	27 90	2 80	21 12	2 80	68 20	19 12	117 22	98 1

Average Annual Gain Per Acre.

Plot 1	$39 52	1904	$ 3 7
" 2	53 12	1905	46 6
" 3	41 92	1906	64 0
" 4	23 96		
" 5	32 70		

The Soil Improvement Experiment.

All of the ten plots in this experiment were seeded to rye in the fall of 1904. The crop which had made a fairly good growth was plowed under in the spring, and half of the area planted with white potatoes and the other half with sweet potatoes. The yields were not good, though the quality of both white and sweet potatoes was excellent. The season accounted for the low yields, being very dry immediately after the rye was plowed under, hence a large number of the sweet potato plants died, and the potato seed did not germinate well. A very marked improvement was noted, none the less, in the character of the soil. Crimson clover was seeded on the entire area in the fall of 1905, and promised to yield a good crop to be plowed under. Unfortunately, much damage was done to it by chickens, and the yield was not satisfactory. Cow peas were planted on the entire area in the spring of 1906, each one-tenth acre plot being devoted to a different variety. The germination of the cow peas was good, and the growth, on the whole, quite satisfactory. The seed was allowed to mature and was collected and weighed separately for

each variety. No attempt was made to keep the vines from the different plots separate, but they were collected in one mass and weighed. They were found to weigh 2,655 pounds. The cow pea seed from each plot was collected separately, measured, and stored for future use. The names of the varieties, and the yield of each are given in the following table:

Yield of Cow Pea Seed.

Plot.	Variety.	Yield per Plot.				Yield per Acre.			
1	Taylor	1	bushel,	7	quarts	12	bushels,	6	quarts
2	Warren's Extra Early	1	"	25	"	17	"	26	"
3	*Large Black Eye*	0	"	27	"	8	"	14	"
4	*California Black Eye*	0	"	30	"	9	"	12	"
5	Early Black	0	"	30½	"	9	"	17	"
6	New Era	2	"	2	"	20	"	20	"
7	*Warren's New Hybrid Variety* of Soy Beans	1	"	5	"	11	"	18	"
8	Early Black	0	"	13½	"	4	"	7	"
9	Medium Yellow	0	"	30¼	"	9	"	17	"
10	Medium Green	0	"	30½	"	9	"	17	"

Very decided differences are shown by the different varieties in the yield of seed. The highest return was secured from the New Era, which produced at the rate of more than twenty bushels per acre. The lowest return was secured from the Early Black, which produced at the rate of only four bushels, seven quarts per acre. With returns like these from the New Era, it would prove profitable to grow cow peas for seed. This is the more probable in view of the fact that the soils of the cow pea plots have not been improved to the extent to which the forage crop plots have been improved. It would be only reasonable to expect that these soils will be more productive within a year or two, and will then demonstrate in a more marked degree their capacity for the profitable production of cow pea or soy bean seed.

Field Experiments With Fertilizers Upon Asparagus.

In 1900 an experiment was begun upon the farm of Mr. C. C. Hulsart *to test primarily the effect of different forms of nitrogen* upon the growth of asparagus. The soil, a sandy loam, was well

suited for the crop, and situated in the asparagus district of t State. Four plots were included, each plot 294 by 12 feet, a containing two rows six feet apart, or one-eighth of an acre area. These were long and narrow, so as to inclue all inequa ties of the soil, although it appears very uniform in characte Previous to setting the plants of the Palmetto variety in t spring of 1900 there was broadcasted over the entire area 1' pounds of acid phosphate and 75 pounds of muriate of potas which was well cultivated into the surface. This application w made to insure the presence in the soil of an abundance of t mineral constituents. The treatment in other respects was follows:

Plot.	1900-01 Lbs. per Plot.	1901-2 Lbs. per Plot.	1902-03 Lbs. per Plot.	1903-04 Lbs. per Plot.	1904-05 Lbs. per Plot.	1905-06 Lbs. per Plot.	1906- Lbs. Plo
1 Nitrate of Soda	15	25	30	30	30	30	3(
2 Sulphate of Ammonia	12	20	24	24	24	24	2
3 Dried Blocd	20	30	36	36	36	36	3
4 Nitrate of Soda	5	8	10	10	10	10	1(
Sulphate of Ammonia	4	6.6	8	8	8	8	[illegible]
Dried Blood	6.8	10	12	12	12	12	1

One-half of the nitrate of soda was applied in 1900 at tir of setting the plants, and the remainder in July. In subseque years, one-half of the nitrate was applied to plot 1, as soon as t plants showed evidence of growth, and the remainder after cu ting had ceased. All other nitrogenous materials, as well as t minerals, acid phosphate and muriate of potash, which were us annually, as indicated for 1900, were applied at the time t first application of nitrate was made, namely, when plants fi showed evidence of growth. The cultivation and treatme were carried on carefully each year, and the weight of tops r corded annually, and the yields and prices of the differents cu since 1902.

In 1902, rust was noticeable on the plants; in 1903, they we practically free from rust or insects, and in 1904, the rust w again very evident before the end of September. There were marked differences in the proportionate amount of rust on t different plots. In 1905, the rust made its appearance towar the end of September and by the 1st of October the tops we quite brown. The season of 1905 was, on the whole, quite dr

'he season of 1906 was marked by several cool periods during he cutting season and involved thereby some reduction in 'ield. The rust did not make its appearance until the end of he growing season. Cutting began in 1902, and while the 'ields were light for a time, noticeable and uniform variations re apparent in both the yield and value of the crops, due to the lifferent forms and combinations of nitrogen used. The prices or the different cuttings varied somewhat, but since there were o marked differences in earliness the total values only have been 'alculated.

	Yield and Value per Plot. 1902.		Yield and Value per Plot. 1903.		Yield and Value per Plot. 1904.		Yield and Value per Plot. 1905.		Yield and Value per Plot. 1906.	
	lbs.	Value.	lbs.	Value.	lbs.	Value.	lbs.	Value.	lbs.	Value.
lot 1........	24	$.80	67	$4 72	180	$9 93	221.25	$14 79	207.50	$13 34
" 2........	20.5	.69	61	4 27	181.5	8 97	227.75	15 76	199.00	12 10
" 3........	23.25	.79	58.5	4 08	162	8 01	211.25	14 59	185.50	11 63
" 4........	19.75	.68	56	3 95	151	7 65	193.50	13 60	166.50	10 32

	Total Yield. lbs.	Value per Plot.	Value of five Crops per Acre.
Plot 1..............................	699.75	$47 44	$474 40
" 2..............................	683.75	45 27	452 70
" 3..............................	640.75	42 36	423 60
" 4..............................	587.00	39 27	392 27

It will be observed that the yield from plot 1 is greater than hat from any of the others with a corresponding increase in 'alue, thus confirming the results secured at the end of the third 'ear's cropping. In 1905 only did plot 2 exceed in yield and 'alue that of plot 1.

REPORT OF THE SOIL CHEMIST AND BACTERIOLOGIST.

SOIL CHEMIST AND BACTERIOLOGIST.

ıemical and Bacteriological Factors in the Ammonification of Soil Nitrogen.

BY JACOB G. LIPMAN.

Earlier ammonification studies[1] seemed to indicate that the ›composition of nitrogenous substances by soil bacteria should ‹ regarded as a function of the chemical and mechanical com›sition of the soil and of the character of its bacterial flora. ıe numbers and species of the soil organisms found in different ils are not a fixed quantity, neither is the physiological effi›ncy of any given species. Moisture and temperature condi›ns, the fineness of division of the soil particles, the amount and ıality of organic matter, the chemical constitution of the rock ıgments, the fertilizers and manures applied, and the crops own each play a direct part in determining the quality and ıantity of bacterial development. But as to the exact signifiınce of each of these factors, our knowledge is very limited. ıe facts in our possession bearing on this question are too few permit of broad deductions and the establishment of general inciples. It will not be disputed, however, that such broad ductions, based on facts well authenticated, are eminently sirable. Concerning as they do the fortunes of the soil nitrogen, ey would give us methods for the more effective conservation ıd utilization of the latter, and would provide us with a means r the rapid and accurate determination of the nitrogen requireents of any given soil.

The recognition of this fact, stimulated by the increasing cost fertilizer nitrogen, has been responsible for systematic study of rtain physiological groups of soil bacteria, among them the

[1] New Jersey Station Rep., 1905, p. 225.

species which accomplish the gradual simplification of protein compounds with the final evolution of ammonia. The experiments recorded in this paper deal with the activities of the last named group of organisms, and attempt to draw a distinction between the individual factors concerned in the ammonification of soil nitrogen, factors on the one hand purely chemical, as affected by the composition and fertilizer treatment of the soil and, on the other hand, bacteriological, as affected by the numbers, species, and the physiological efficiency of the organisms represented.

In defining the influence of each of the factors referred to above, it became necessary to study the modifications produced in culture solutions by the bacteria themselves apart from the soil from which they are derived. It became necessary, likewise, to determine the influence on ammonification of definite quantities of sterile soils. Two methods suggested themselves for the study of this problem.

The soil bacteria could be brought into suspension by shaking weighed quantities of soil in a measured amount of sterile water and the infusion thus formed could be used for the inoculation of nutrient solutions with or without the presence of equivalent quantities of sterile soil. Similar nutrient solutions provided with sterile soil could also be inoculated from a pure culture of one of the more common soil organisms. It was proposed, therefore, to prepare a number of such infusions for comparison among themselves with or without the corresponding soils. Assuming that all, or practically all, of the bacteria can thus be brought into suspension, the action of any volume of the soil infusion corresponding to a definite quantity of soil, should be the same as that of the soil itself, where such action is due entirely to the bacteria. If, on the other hand, such action results only from the combined influence of soil and bacteria the soil infusion alone should not produce the same effect as that produced by the soil. If the latter be true, the combined influence of the soil infusion and of a corresponding quantity of sterile soil should produce the same effect as that produced by the non-sterile soil. Furthermore, if the process of ammonification in nutrient solutions, is affected by

the chemical composition of the soil used, equal quantities of sterile soil should influence differently the process of ammonification by a pure culture of some soil organism.

Series I.

With these facts in mind, two nutrient solutions were prepared, one of them designated as *peptone*, and containing 10 gms. of Witte's peptone per liter, the other designated as *peptone salt* and containing in addition to the peptone, .1 gms. K_2HPO_4, .2 gms. $MgSo_4$, .02 gms. $CaCl_2$, a trace of ferric chloride, and enough sodium hydrate to render the whole slightly alkaline to phenolphthaleine. Tap-water was used in each case. These solutions were distributed in 100 cc. portions, in flat-bottomed 500 cc. Jena flasks, sterilized in the autoclave at 1 3/4 atmospheres of pressure, cooled, and inoculated with soil, soil infusion, or pure cultures. Ammonia determinations were made at the end of three and of six days, respectively, by the addition to the cultures of magnesia, the distillation into standard hydrochloric acid, and the titration of the distillate against standard ammonia. The four soils used in this experiment were of the following origin:

1. Lawn soil; a heavy clay loam soil taken from the Station lawn, and well provided with organic matter and mineral plant food.

2. Vineland soil; a sandy loam soil from Vineland, secured two years previously, and kept after that in a moist condition in a glass-stoppered bottle.

3. Hainesport soil; a coarse grained, sandy soil, poor in humus.

4. Greenhouse soil; an artificial soil containing a large proportion of composted manure.

Where used directly, these soils were weighed off on the torsion balance in 10-gm. quantities for each 100 cc. portion of the nutrient solution. The soil infusions were prepared by shaking 150 gms. of soil with 300 cc. of sterile tap-water for one to three minutes, and using 20 cc. of this, equivalent to 10 gms. of soil, for inoculation. The spatula and pipette used were sterilized after each set of inoculations. The cultures were kept at room temperature, ranging from 16° to 20° C.

Scheme of Inoculation.

Culture No.	*Culture solution* kept sterile.	Culture No.	Inoculated with 10 gms. of soil.	Culture No.	Inoculated with 10 gms. soil, sterilized, and inoculated with 20 cc. corresponding infusion.	Culture No.	Inoculated with 10 gms. lawn soil, sterilized, and inoculated with 20 cc. different infusion.	Culture No.	Inoculated with 10 gms. *Vineland* soil, sterilized, and inoculated with 20 cc. different infusion.	Culture No.	Inoculated with 10 gms. soil, sterilized, and inoculated with B. mycoides.	Culture No.	No soil. Inoculated with 20 cc. soil infusion.
100 cc. Peptone.													
1, 2....	No soil..........	7, 8.	Lawn soil........	15, 16.	Lawn soil........	23, 24.	Vineland infusion...	29, 30.	Lawn infusion..	35, 36.	Lawn soil........	....	....
3....	Lawn soil........	9, 10.	Vineland soil........	17, 18.	Vineland soil........	25, 26.	Hainesport infusion...	31, 32.	Hainesport infusion...	37, 38.	Vineland soil........	....	....
4....	Vineland soil........	11, 12.	Hainesport soil	19, 20.	Hainesport soil........	27, 28.	Greenhouse infusion...	33, 34.	Greenhouse infusion...	39, 40.	Hainesport soil........	....	....
5....	Hainesport soil	13, 14.	Greenhouse soil........	21, 22.	Greenhouse soil	....	....	....	....	41, 42.	Greenhouse soil	....	....
6....	Greenhouse soil........	....	....	....	....	....	....	....	....	....	....	....	....
100 cc. Peptone Salt.													
43, 44.	No soil..........	49, 50.	Lawn soil........	57, 58.	Lawn soil........	65, 66.	Vineland infusion...	71, 72.	Lawn infusion..	77, 78.	Lawn soil........	85, 86.	Lawn soil infusion.
45.	Lawn soil........	51, 52.	Vineland soil........	59, 60.	Vineland soil........	67, 68.	Hainesport infusion...	73, 74.	Hainesport infusion...	79, 80.	Vineland soil........	87, 88.	Vineland soil infusion.
46.	Vineland soil	53, 54.	Hainesport soil	61, 62.	Hainesport soil	69, 70.	Greenhouse *infusion*...	75, 76.	Greenhouse *infusion* ..	81, 82.	Hainesport soil........	89, 90.	Hainesport *soil infusion.*
47.	Hainesport soil	55, 56.	Greenhouse soil	63, 64.	Greenhouse soil	....	....	....	....	83, 84.	Greenhouse soil........	91, 92.	Greenhouse soil infusion.
48.	Greenhouse soil........	....	....	....	....	....	....	....	....	....	....	....	....

As will be seen from the above scheme, the inoculations were performed in duplicate. Ammonia determinations were made in one of each set at the end of three and six days, respectively. The several inoculations gave the following results :

Inoculations with Ten Grams of Soil.

	In 3 Days.		In 6 Days.	
	Peptone.	Peptone Salt.	Peptone.	Peptone Salt.
Lawn Soil.	17.02 mg.	14.29 mg.	57.76 mg.	70.83 mg.
Vineland Soil	6.08 "	5.47 "	34.66 "	64.30 "
Hainesport Soil	5.66 "	8.51 "	27.36 "	63.54 "
Greenhouse Soil	*11.24* "	*12.92* "	62.93 "	*71.90* "
Average	8.00 "	8.30 "	45.64 "	67.64 "

The amounts of ammonia nitrogen produced in the different cultures show distinct variations. The lawn soil produced by far the greatest amount of ammonia in the peptone solution at the end of three days. It was followed in the order named by the greenhouse, Vineland and Hainesport soils. In the peptone salt solutions the relations were somewhat different at the end of three days. There were apparently smaller amounts of ammonia produced by the lawn and Vineland soils, and larger amounts by the Hainesport and greenhouse soils.

At the end of six days, the peptone solutions showed the same relations except that the greenhouse soil showed a greater power of ammonification than did the lawn soil. The peptone salt solutions, at the end of the same period, while retaining these differences, showed them only within narrow limits. These results indicate, therefore, that, under the conditions of the experiment, the development of certain species of ammonifying bacteria was favored by the addition of the salts; that these species are unequally represented in the different soils, and hence at the end of three days interesting variations became apparent in both solutions, variations that were apparent, also, at the end of six days in the peptone solutions and to a much slighter extent in the peptone salt solutions.

Ten Grams of Soil, Sterile + 20 cc. Corresponding Infusion.

	In 3 Days.		In 6 Days.	
	Peptone.	Peptone Salt.	Peptone.	Peptone Salt.
Lawn Soil.....................	6.23 mg.	12.31 mg.	35.42 mg.	65.21 mg.
Vineland Soil..................	4.10 "	4.26 "	27.21 "	37.54 "
Hainesport Soil............	3.80 "	8.66 "	18.45 "	60.04 "
Greenhouse Soil..............	6.08 "	6.69 "	39.98 "	60.80 "
Average	5.05 "	7.98 "	30.26 "	55.90 "

A comparison of this with the preceding group of inoculations shows that the equivalent amounts of soil infusion were decidedly inferior to the soil itself. This is more evident in the peptone solutions than in the peptone salt solutions. Thus, at the end of three days there were produced on the average 8.00 *mg. and 5.05 mg. of ammonia nitrogen in* the soil and soil infusion inoculations, respectively, and at the end of six days 45.64 mg. and 30.26 mg., respectively. The corresponding figures for the peptone salt solutions were 8.30 mg. and 7.98 mg., and 67.64 mg. and 55.90 mg., respectively. Otherwise, the relations brought out by the two groups of inoculations are quite similar. As in the preceding group, we find the production of ammonia by the four soils in the following order: Lawn soil, greenhouse soil, Vineland soil and Hainesport soil in the peptone solutions at the end of three days, and greenhouse soil, lawn soil, Vineland soil and Hainesport soil at the end of six days. In the peptone solutions, the order is: Lawn soil, greenhouse soil, Hainesport soil and Vineland soil at the end of three days, and also at the end of six days in the soil infusion inoculations. On the whole, the differences noted above indicate deep-seated variations in the bacteriological composition of the soils under experiment.

Ten Grams of the Same Soil, Sterile + 20 cc. of Different Infusions.

	In 3 Days.		In 6 Days.	
	Peptone.	Peptone Salt.	Peptone.	Peptone Salt.
Lawn Soil, Vineland Infusion............	4.26 mg.	5.78 mg.	28.27 mg.	54.87 mg.
Lawn Soil, Hainesport Infusion.........	4.86 "	12.62 "	23.10 "	69.16 "
Lawn Soil, Greenhouse Infusion.........	5.93 "	7.30 "	36.02 "	60.65 "
Vineland Soil, Lawn Infusion............	7.60 "	10.49 "	34.81 "	68.25 "
Vineland Soil, Hainesport Infusion....	4.26 "	Lost	18.85 "	62.78 "
Vineland Soil, Greenhouse Infusion...	6.08 "	5.17 "	37.09 "	44.99 "

The amounts of ammonia-nitrogen produced by the different soil infusions in the presence of 10 grams of sterile lawn soil do not differ materially from those produced in the corresponding peptone cultures of the preceding group. At the end of three days the lawn soil and Vineland infusion were slightly superior to the Vineland soil and Vineland infusion; whereas the lawn soil and Hainesport infusion proved slightly inferior to the Hainesport soil and Hainesport infusion. These differences are somewhat more pronounced at the end of six days. In the peptone salt solutions the influence of the lawn soil is decidedly more striking. The gain is greatest in the lawn soil-Hainesport infusion at the end of three days, and in the lawn soil-Vineland infusion at the end of six days. The lawn soil-greenhouse infusion at the end of six days should not be included in the comparison, since for lack of material only 10 cc. of infusion, equivalent to 5 gms. of soil, were used here for inoculation.

With sterile Vineland soil as a basis, the amounts of ammonia produced in the peptone solutions at the end of three days by the lawn and Hainesport soil infusions were somewhat greater than in the cultures with the corresponding soils. Comparatively small differences appear also in the peptone solutions at the end of six days. In the peptone salt solutions, at the end of three days, the Vineland soil-lawn infusion was somewhat inferior to the lawn soil-lawn infusion, and the Vineland soil-greenhouse infusion somewhat inferior to the greenhouse soil-greenhouse infusion. At the end of the six-day period, the Vineland soil-lawn infusion yielded more ammonia-nitrogen than did the corresponding lawn soil-lawn infusion. The Vineland soil-Hainesport infusion, and the Vineland soil-greenhouse infusion should not be included in the comparison, since only 10 cc. and 4 cc., respectively, of soil infusion were used here for inoculation. On the whole, it is quite evident here that the bacteriological factor played in this experiment a more important role than did the chemical factor, since the Vineland soil-lawn infusions, representing the ammonifying activities of the bacteria in the lawn soil proved superior in every case to the lawn soil-Vineland infusions where the ammonification was caused by the

Vineland soil bacteria. It appears, thus, that under the given conditions ammonification was influenced both by the chemical composition of the soil as well as the species relationships of certain groups of its bacteria.

20 cc. Infusion in Peptone Salt Solutions.

	In 3 Days.	In 6 Days.
Lawn Soil Infusion	8.66 mg.	71.29 mg.
Vineland Soil Infusion	4.10 "	21.43 "
Hainesport Soil Infusion	4.41 "	58.06 "
Greenhouse Soil Infusion	3.19 "	39.06 "

The above figures represent the yields of ammonia-nitrogen in peptone salt solutions, which did not contain any sterile soil, and which were inoculated with 20 cc. quantities of soil infusion, equivalent to 10 grams of soil. The yields here are, therefore, comparable with the peptone salt inoculations of group two. It *will be noted here that the amounts of ammonia-nitrogen pro-*duced here at the end of three days are smaller throughout than the corresponding amounts in group two. The same is true, with one exception, also of the yields at the end of the six-day period. The decreased ammonification is particularly noticeable at the end of the three-day period, in the Hainesport and greenhouse soils, and at the end of the six-day period in the case of the Vineland and greenhouse soils. It would seem again, therefore, that the presence of the soil itself does affect the progress of ammonification, whether by stimulating the growth of certain species by furnishing mineral nutriment to them, or by neutralizing certain injurious products of their metabolism.

Ten Grams of Soil, Sterile + Pure Cultures.

	B. mycoides in 6 Days.		**B. mycoides + B.** *aurantiacus in 6 Days.*	
	Peptone.	Peptone Salt.	Peptone.	Peptone Salt.
Lawn Soil	5.00 mg.	5.17 mg.	4.86 mg.	8.97 mg.
Vineland Soil	6.08 "	6.08 "	5.93 "	5.62 "
Hainesport Soil	3.65 "	4.26 "	3.65 "	4.10 "
Greenhouse Soil	7.75 "	7.45 "	7.75 "	6.84 "

The influence of the chemical composition of the soil is quite apparent in the above inoculations. The parallel determinations in the peptone and peptone salt solutions agree quite well, and it appears that the ammonification of the peptone by B. mycoides was favored most by the greenhouse soil, and then by the Vineland, lawn and Hainesport soils in the order named. Where B. aurantiacus was inoculated together with B. mycoides, the relations are not materially changed, except in the case of the lawn soil, where there was an increased yield in the peptone salt solution. We note again, therefore, that, in this experiment, the ammonification of the peptone was markedly influenced by the chemical composition of the soil, through its action on the organisms multiplying in the culture solution. We do not know to what an extent these relations find an analogy in actual field conditions, yet the assumption seems justified that such relations do exist in the field, and that the modifications of the chemical factor as accomplished by manuring, fertilizer treatment, or crop rotation, are not followed by identical modifications of the bacteriological factors in soils of different origin.

Ammonia-Nitrogen Present in the Sterile Solutions.

	Peptone.	Peptone Salt.
Culture Solution	.92 mg.	1.80 mg.
" "	.92 "	1.23 "
" " +10 gms. Lawn Soil	1.80 "	1.80 "
" " +10 " Vineland Soil	1.07 "	1.07 "
" " +10 " Hainesport Soil	1.23 "	1.80 "
" " +10 " Greenhouse Soil	1.68 "	1.68 "

The quantities of ammonia-nitrogen found in the sterile solutions were comparatively slight, and do not affect seriously the quantitative relations as presented in the above tables.

Series II.

The soil infusions of the preceding series were secured by shaking weighed quantities of soil in twice the volume of sterile water for a period ranging from one to three minutes, and the certainty was lacking that this rather brief and irregular period

was sufficient to bring all of the soil bacteria in suspension. It seemed desirable to test this question experimentally with at least two soils of different origin, and, accordingly, the following experiment was arranged. The lawn and greenhouse soils used here were the same as those used in series I. They were placed in sterile vessels, thoroughly mixed, and the portions used were removed with a sterile spatula. The peptone and peptone salt solutions were of the same composition as those of series I. The soil infusions were obtained by shaking 150 gms. of the corresponding soil in 300 cc. of sterile tap-water for 1 minute, 3 minutes, 5 minutes and 10 minutes, respectively. The portions used for inoculation were drawn off with a sterile pipette, the 20 cc. employed in each case being regarded as equivalent to 10 grams of soil.

Scheme of Inoculation.

100 cc. Peptone Solution.

Soil or Infusion Used.	Lawn Soil. *Culture No.*	Greenhouse Soil. *Culture No.*
10 gms. of soil	1, 2, 3, 4	21, 22, 23, 24
10 gms. soil, sterile + 20 cc. 1-minute infusion	5, 6, 7, 8	25, 26, 27, 28
10 gms. soil, sterile + 20 cc. 3-minute infusion	9, 10, 11, 12	29, 30, 31, 32
10 gms. soil, sterile + 20 cc. 5-minute infusion	13, 14, 15, 16	33, 34, 35, 36
10 gms. soil, sterile + 20 cc. 10-minute infusion	17, 18, 19, 20	37, 38, 39, 40

100 cc. Peptone Salt Solution.

10 gms. of soil	41, 42, 43, 44	61, 62, 63, 64
10 gms. soil, sterile + 20 cc. 1-minute infusion	45, 46, 47, 48	65, 66, 67, 68
10 gms. soil, sterile + 20 cc. 3-minute infusion	49, 50, 51, 52	69, 70, 71, 72
10 gms. soil, sterile + 20 cc. 5-minute infusion	53, 54, 55, 56	73, 74, 75, 76
10 gms. soil, sterile + 20 cc. 10-minute infusion	57, 58, 59, 60	77, 78, 79, 80

The cultures were kept at room temperature, ranging from 18° to 22° C. Of the four parallel inoculations, in each case two were analysed at the end of three days, and two at the end of four days.

Amounts of Ammonia-Nitrogen Found in 3 Days.

Peptone.

	Lawn Soil.		Greenhouse Soil.	
Soil	17.62 mg.		12.87 mg.	
Soil	17.47 "	Av. 17.50 mg.	12.11 "	Av. 12.49 mg.
1-Minute Infusion	20.69 "		7.20 "	
1-Minute Infusion	20.69 "	" 20.69 "	7.69 "	" 7.83 "
3-Minute Infusion	18 54 "		8.58 "	
3-Minute Infusion	19.16 "	" 18.85 "	9.19 "	" 8.88 "
5-Minute Infusion	20.38 "		12.11 "	
5-Minute Infusion	18.70 "	" 19.54 "	11.80 "	" 11.95 "
10-Minute Infusion	18.54 "		11.03 "	
10-Minute Infusion	18.54 "	" 18.54 "	10.42 "	" 10.72 "

Peptone Salt.

	Lawn Soil.		Greenhouse Soil.	
Soil	16.24 mg.		14.34 mg.	
Soil	16.09 "	Av. 16.16 mg.	13.79 "	Av. 14.06 mg.
1-Minute Infusion	17.78 "		4.44 "	
1-Minute Infusion	14.34 "	" 16.06 "	4.44 "	" 4 44 "
3-Minute Infusion	22.68 "		5.21 "	
3-Minute Infusion	24.98 "	" 23.83 "	4.60 "	" 4.90 "
5-Minute Infusion	22.22 "		7.51 "	
5-Minute Infusion	21.91 "	" 22.06 "	6.44 "	" 6.97 "
10-Minute Infusion	23.75 "		7.81 "	
10-Minute Infusion	25.59 "	" 24 67 "	7.51 "	" 7.66 "

It should be remembered in the comparison of the above figures that the direct soil inoculations contained a smaller volume of culture medium than did the corresponding cultures to which 20 cc. of soil infusion had been added. Slight differences were created thereby, as they were also in Series I, hence in the subsequent series an attempt was made to remedy this by the addition to the direct soil inoculations of 20 cc. of tap-water.

Interesting differences become apparent in the behavior of the two soils. It will be noticed that in the case of the lawn soil the 1-minute infusion was as effective (in fact more effective), as the 3, 5, or 10-minute infusions. In the case of the greenhouse soil, on the other hand, the highest yield of ammonia was produced by the 5-minute infusion. Another marked difference, as shown by the two soils, is found in the yields of ammonia in the direct soil inoculations. It will be noted that the lawn soil in-

oculation yielded, in the more concentrated solution, less am monia than was produced by the soil infusions, whereas in th case of the greenhouse soil the reverse was true.

The differences are no less interesting in the case of the pep tone salt solutions. The highest degree of ammonification wa produced in the lawn soil inoculations by the 10-minute infu sion. The direct soil inoculations, as well as the 1-minute infu sion yielded less ammonia than did the others. *It thus appear* that the soil inoculations, as well as the 1-minute infusion, wer less effective in the presence of the salts added to the peptone *Conversely, the 3, 5 and 10-minute infusions were more effectiv* in the presence of the salts. The relations disclosed in the case of the greenhouse soil inoculations are even more instructive The highest yields of ammonia-nitrogen were secured here from the direct soil inoculations, yields greater than those in the cor responding peptone solutions. On the other hand, there was here a remarkable reduction in the yields of ammonia-nitrogen, where soil infusion was used as inoculating material. Thus the 1-minute infusion yielded, on the average, only 4.44 mg. of ammonia-nitrogen, as against a corresponding yield of 7.83 mg. in the peptone solutions. This yield was gradually increased until in the 10-minute infusion there was an average yield of 7.66 mg. Still, even the latter was much inferior to the yields of ammonia in the corresponding peptone solutions. The interpretation of these results is rendered more difficult by the fact that in the method followed there are non-bacteriological factors introduced which undoubtedly play some influence in determining the final results. Thus in the course of agitation of the soil in sterile water there are quantities of mineral and organic substances dissolved which are not the same in the 1, 3, 5 and 10-minute infusions. Moreover, the 10 grams of soil in the direct soil inoculations being constantly in contact with the culture solution undoubtedly exert through their absorptive power some influence on the process of ammonification. Finally the peptone solutions contained in each case 10 grams of sterile soil, besides the corresponding infusion, whereas in the peptone salt solutions the infusions alone were added.

In Four Days.

Peptone.

	Lawn Soil.		Greenhouse Soil.	
ɔil........................	38.62 mg.		33.71 mg.	
ɔil........................	36.17 "	Av. 37.39 mg.	31.88 "	Av. 32.79 mg.
Minute Infusion......	41.22 "		23.60 "	
Minute Infusion	43.68 "	" 42.45 "	22.37 "	" 22.98 "
Minute Infusion......	46.59 "		25.25 "	
Minute Infusion......	42.14 "	" 44.36 "	24.67 "	" 24.98 "
Minute Infusion......	47 20 "		30.50 "	
Minute Infusion	41.68 "	" 44.44 "	30.19 "	" 30.34 "
Minute Infusion......	41.53 "		26.82 "	
Minute Infusion......	42.14 "	" 41.83 "	29.88 "	" 28.85 "

Peptone Salt.

	Lawn Soil.		Greenhouse Soil.	
ɔil........................	54.71 mg.		38.31 mg.	
ɔil........................	44.44 "	Av. 49.57 mg.	37.24 "	Av. 37.77 mg.
Minute Infusion......	49.04 "		22.37 "	
Minute Infusion......	48.89 "	" 48.96 "	20.38 "	" 21.37 "
Minute Infusion......	65.63 "		14.86 "	
Minute Infusion......	56.70 "	" 61.16 "	16.70 "	" 15.78 "
Minute Infusion......	65.28 "		22.22 "	
Minute Infusion......	64.06 "	" 64.67 "	22.99 "	" 22.60 "
Minute Infusion	66.05 "		28.20 "	
Minute Infusion	66.20 "	" 66 12 "	28.35 "	" 28.27 "

The yields of ammonia-nitrogen at the end of four days bring t the same relations noted at the end of the three-day period. e see also here that the soil inoculations gave the smallest elds in the case of the lawn soil, and the largest yields in the se of the greenhouse soil, in the peptone solutions. The 1-min- e infusion proved as effective as the 10-minute infusion, and t slightly less effective than the 3 and 5-minute infusions the case of the lawn soil. The 1-minute infusion of the green- use soil was not only markedly inferior to the corresponding ect soil inoculation, but also inferior to the 3-minute infusion, d still more inferior to the 5-minute infusion. As at the end the three-day period, the 10-minute infusion yielded somewhat s ammonia-nitrogen than did the 5-minute infusion.

Also, in the peptone salt solutions the results were, on the iole, in agreement with those secured at the end of the three- y period. It will be noted, in the first place, that in the case

of the lawn soil, the direct soil inoculations, and the 1-mi infusions yielded, on the average, nearly the same results. A that there was a distinct increase in the yields of ammo nitrogen for the 3, 5 and 10-minute infusions. In the cas *the greenhouse soil* the largest yield of ammonia-nitrogen due to the direct soil inoculations. The yields were mark smaller in the soil infusion cultures. Thus there was a dim tion from 37.77 mg. of ammonia-nitrogen to 21.37 mg. betw the direct soil inoculation and the 1-minute infusion inoculat A further decrease occurred between the 1-minute and th minute infusions, and after that an increase to the 5-minute fusion, and a still greater increase to the 10-minute infusi Striking differences are again indicated between the two sc differences that might be partly but not wholly accounted for the partial ammonification of the comparatively large proport of nitrogen in the greenhouse soil. It seems desirable to pur this investigation further on a number of soils of different ori and composition, and in culture media of varying constituti so that differences may be discovered in the species relations of the several groups of ammonification bacteria.

Series III.

The present series consists of a study of the ammonify power of a number of soils of the same origin, but differentia by fertilizer treatment. The eight soils employed for this p pose were secured from the asparagus plots on the College Fa Since the beginning of the asparagus experiment in 1896, th soils have been receiving the following fertilizer treatment:

Plots	*I. and V*...........	*20 tons of yard manure, applied in fall.*
"	II. and VI...........	500 lbs.* complete fertilizer, applied in spring.
"	III. and VII...........	500 lbs.* complete fertilizer, in spring, + 300 lbs. bone and potash, in fall.
"	IV. and VIII...........	500 lbs.* complete fertilizer, in spring, + 300 lbs. bone and potash, in fall, + 200 lbs. nitrate of soda, in late spring

* 1,000 lbs. in 1906.

Soils V., VI., VII. and VIII. were irrigated whenever the rain-l seemed insufficient for optimum moisture conditions.

The total yield, in 1906, for the unirrigated plots was as follows:

Plot	I	314 lbs.
"	II	292 "
"	III	293 "
"	IV	270 "

It should be pointed out here that the land slopes gently from its I. to IV., and likewise from the parallel irrigated plots V. to II. Differences in drainage and mechanical constitution are as introduced here, which serve as an important factor in termining the yield. Hence, the comparative ammonifying wer of the several soils should not be taken as a measure of nitrogen supply in the different plots, but rather as a measure conditions favorable or unfavorable to bacterial development.

Scheme of Inoculation.

Culture No.	100 cc. peptone + 20 cc. tap-water, inoculated with 10 gms. of soil.	Culture No.	100 cc. salt peptone + 20 cc. soil infusion.	Culture No.	100 cc. peptone, 10 gms. soil sterile + 20 cc. corresponding infusion.	Culture No.	100 cc. peptone, 10 gms. soil I., sterile, + 20 cc. soil infusion.	Culture No.	100 cc. peptone + 10 gms. different soil + 20 cc. infusion I.
1, 2...	Soil I............	17, 18...	Soil Infusion I..........	33, 34...	Soil I., Infusion I..	49, 50...	Soil I., Infusion I.......	65, 66...	Soil I., Infusion I.
3, 4...	" II............	19, 20...	" " II..........	35, 36...	" II., " II..	51, 52...	" I., " II.......	67, 68...	" II., " I.
5, 6...	" III............	21, 22...	" " III..........	37, 38...	" III., " III..	53, 54...	" I., " III.......	69, 70...	" III., " I.
7, 8...	" IV............	23, 24...	" " IV..........	39, 40...	" IV., " IV..	55, 56...	" I., " IV.......	71, 72...	" IV., " I.
9, 10...	" V............	25, 26...	" " V..........	41, 42...	" V., " V..	57, 58...	" I., " V.......	73, 74...	" V., " I.
11, 12...	" VI............	27, 28...	" " VI..........	43, 44...	" VI., " VI..	59, 60...	" I., " VI.......	75, 76...	" VI., " I.
13, 14...	" VII............	29, 30...	" " VII..........	45, 46...	" VII., " VII..	61, 62...	" I., " VII.......	77, 78...	" VII., " I.
15, 16...	" VIII............	31, 32...	" " VIII..........	47, 48...	" VIII., " VIII..	63, 64...	" I., " VIII.......	79, 80...	" VIII., " I.

The samples were collected with the customary precautions gainst contamination, and the infusions prepared and inoculaions performed in the manner indicated in the preceding series. 'he cultures were kept at room temperatures ranging from 18° › 22° C., and the ammonia determinations were made at the nd of three and four days, respectively. The following quantities of ammonia-nitrogen were found :

Inoculations with 10 gms. of Soil.

	In 3 Days.	In 4 Days.	
sparagus Soil I	29.58 mg.	49.81 mg.	Av. 39.69 mg.
" " II	22.99 "	43.06 "	" 33.02 "
" " III	22.99 "	43.52 "	" 33.25 "
" " IV	21.30 "	37.70 "	" 29.50 "
" " V	28.35 "	51.64 "	" 40.00 "
" " VI	23.29 "	48.43 "	" 35.86 "
" " VII	19.92 "	40.00 "	" 29.96 "
" " VIII	29.27 "	41.84 "	" 35.55 "

The yields of ammonia-nitrogen in the parallel plots agree iirly well on the whole. The only exception to be noted here the low yield at the end of the four-day period in soil VIII. is more likely, however, that the yield at the end of the threeay period was for some reason considerably higher than it iould have been. Further examination shows that there has een undoubtedly some bacteriological differentiation in the soils 1 question. Thus we find that soils I. and V., which have been :ceiving *annual dressings of manure, possess a markedly greater* nmonifying power than any of the other soils. We find, likeise, that soil IV. is inferior in its power of ammonification to ›ils II. and III. The yields of ammonia-nitrogen seem to bear me relation to the yields of asparagus, for 1906, in soils I., II., [I. and IV., as may be seen from the figures presented above.

Peptone Salt with 20 cc. of Infusion.

	In 3 Days.	**In 4 Days.**	
Infusion Asparagus Soil I........	50.57 mg.	74.17 mg.	Av. 62 37 mg
" " " II........	32.79 "	61.30 "	" 47.04 "
" " " III........	32.33 "	60.53 "	" 46.43 "
" " " IV........	43.68 "	72.02 "	" 57.85 "
" " " V........	43.98 "	76.93 "	" 60.45 "
" " " VI........	35.86 "	70.95 "	" 53.40 "
" " " VII........	32.79 "	61.00 "	" 46.89 "
" " " VIII........	31.71 "	58.39 "	" 45.05 "

It is evident from the above figures that ammonification in the peptone solutions was greatly stimulated by the presence of the mineral salts. It will be noted, at the same time, that the differences were more in degree than in kind. As in the direct soil inoculations, the yields of ammonia-nitrogen were greatest in the manure plots I. and V. On the other hand, the yields of ammonia-nitrogen in soil IV., at the end of both the three-day and the four-day periods, were greater than the corresponding yields in soils II. and III. In the case of the latter, the yields are practically the same, and relatively similar to the corresponding yields in the direct soil inoculations. It may, also, be noted here that the yields of ammonia nitrogen in plots V.–VIII. show a gradual decrease from plot to plot.

Peptone. Ten Grams of Soil, Sterile + 20 cc. Corresponding Infusion.

	In 3 Days.	**In 4 Days.**	
Asparagus Soil I..............	28.66 mg.	52.10 mg.	Av. 40.38 mg.
" " II..............	23.29 "	41.53 "	" 32.41 "
" " III..............	25.44 "	49.81 "	" 37.62 "
" " IV..............	25 44 "	44.59 "	" 35.01 "
" " V..............	28 66 "	51.49 "	" 40.07 "
" " VI..............	25.44 "	39.54 "	" 32.49 "
" " VII..............	24.52 "	45.82 "	" 35.17 "
" " VIII..............	24.98 "	46.74 "	" 35.86 "

The yields of ammonia-nitrogen, as indicated by the above figures, again show the superior ammonifying power of the manure plots I. and V. Beyond that, however, the results are rather unsatisfactory. It would seem that either the sterilization of the

soil, or the solution of certain of the soil constituents in the preparation of the infusion, had introduced new factors. It may be assumed that the large applications of fertilizer on plots III., IV., VII. and VIII., containing potassium salts and calcium phosphate over and above that furnished by the complete fertilizer on plots II. and VI., sensibly affected the character of the infusions. On the other hand, this influence would not be felt in the salt peptone solutions, where a comparative abundance of the mineral salts are supplied. Hence, the peptone salt solutions, not provided with too large a quantity of mineral salts, may become more nearly a measure of the general condition of the bacterial flora in the soil.

Peptone. Ten Grams of the Same Soil, Sterile. Different Infusion.

	In 3 Days.	In 4 Days.	
Asparagus soil I., Infusion I	26.66 mg.	57.31 mg.	Av. 41.98 mg.
" " I., " II	27.74 "	48.12 "	" 37.93 "
" " I., " III	27.12 "	48.58 "	" 37.85 "
" " I., " IV	26.05 "	47.51 "	" 36.78 "
" " I., " V	32.03 "	52.87 "	" 42.45 "
" " I., " VI	25.13 "	45.36 "	" 35.24 "
" " I., " VII	26.51 "	50.57 "	" 38.54 "
" " I., " VIII	27.12 "	51.33 "	" 39.22 "

The arrangement of the inoculations in the above group allows a comparison of the relative values of the several infusions detached from their soils, and brought together with the same sterile soil. It will be seen, therefore, that in the presence of soil I., the several infusions show important differences in their power of ammonification. It will be noted that in the case of soils I.–IV. there is good agreement with the corresponding direct soil inoculations. The bacterial flora of soil I. still maintained its superiority over soils II., III. and IV., while the flora of soil IV. proved inferior to those of soils II. and III. In the case of soil infusions V.–VIII., the first of these maintained its superiority over the others, whereas infusion VIII. proved superior to infusion VI., and also to infusion VII. On the whole, the soil infusions in the presence of one and the same sterile soil, exhibited relations among themselves similar to those in the corresponding direct soil inoculations.

Peptone. Ten Grams of Different Soil, Sterile. The Same Infus

				In 3 Days.	In 4 Days.	
Asparagus soil	I.,	Infusion	I........	28.66 mg.	50.11 mg.	Av. 39.38
" "	II.,	"	I........	26.97 "	49.81 "	" 38.39
" "	III.,	"	I........	29.27 "	52.26 "	" 40.76
" "	IV.,	"	I........	28.35 "	52.87 "	" 40.61
" "	V.,	"	I........	28.20 "	51.49 "	" 39.84
" "	VI.,	"	I........	26.97 "	50.11 "	" 38.54
" "	VII.,	"	I........	25.90 "	48.73 "	" 37.31
" "	VIII.,	"	I........	Lost.	Lost.	

The above group of inoculations allows a comparison of chemical factors in the ammonification of peptone-nitrog Unmistakable differences are apparent also here. In the cas soils I.–IV., the greater applications of fertilizer on plots III. a IV. seem to find expression in a greater stimulus to ammonif tion. On the other hand, this is not brought out in the cas soil VII., as compared with soil VI. of the irrigated plots.

Taking the results of this series in their entirety, we can tr a distinct influence of the soil treatment on its ammonify power. The chemical differentiation has undoubtedly b accompanied by a bacteriological differentiation. It is q certain that with the employment of culture media more sui to this purpose, the differences will be brought out more shar and a more exact measure will thus be secured, not only of processes of decay, as influenced by fertilizer treatment, but a of general soil conditions favorable or unfavorable for the grov of the great mass of soil bacteria.

Series IV.

The present series includes a comparison of the ammonify power of seven soils of different origin. These soils were lected about the middle of April and numbered from 1 to 7, follows:

Soil I. Asparagus soil V. used in series III.
" II. A very heavy clay soil from Matawan.
" III. A sandy loam soil from Matawan.
" IV. A dark-colored clay loam soil from Princeton.
" V. A reddish, sandy loam soil from Clarksville.
" VI. A dark-colored sandy loam from Marlboro.
" VII. A reddish, fine-grained sandy soil from Freehold.

Scheme of Inoculation.

Culture No.	100 cc. peptone, 20 cc. tap-water, sterile, 10 gms. soil.	Culture No.	100 cc. peptone, 10 gms. soil, 20 cc. corresponding infusion.	Culture No.	100 cc. peptone, 10 gms. soil I., sterile, 20 cc. different infusion.	Culture No.	100 cc. peptone, 10 gms. soil, sterile, 20 cc. same infusion.	Culture No.	100 cc. peptone salt, 20 cc. infusion.
1, 2...	Soil I........	15, 16....	Soil I., Infusion I........	29, 30....	Soil I., Infusion I......	43, 44....	Soil I., Infusion I........	57, 58....	Soil Infusion I.
3, 4....	" II........	17, 18....	" II., " II........	31, 32....	" I., " II......	45, 46....	" II., " I........	59, 60....	" " II.
5, 6....	" III........	19, 20....	" III., " III........	33, 34....	" I., " III......	47, 48....	" III., " I........	61, 62....	" " III.
7, 8....	" IV........	21, 22....	" IV., " IV........	35, 36....	" I., " IV......	49, 50....	" IV., " I........	63, 64....	" " IV.
9, 10....	" V........	23, 24....	" V., " V........	37, 38....	" I., " V......	51, 52....	" V., " I........	65, 66....	" " V.
11, 12....	" VI........	25, 26....	" VI., " VI........	39, 40....	" I., " VI......	53, 54....	" VI., " I........	67, 68....	" " VI.
13, 14....	" VII........	27, 28....	" VII., " VII........	41, 42....	" I., " VII......	55, 56....	" VII., " I........	69, 70....	" " VII.

The inoculations were performed in the customary manner, except that non-sterile distilled water was used instead of sterile tap-water in the preparation of infusion II. Determinations of ammonia-nitrogen were made at the end of three and four days, and the following amounts were found:

Inoculations with 10 Grams of Soil.

	In 3 Days.	In 4 Days.	
Soil I	29.14 mg.	45.68 mg.	Av. 37.41 mg.
" II	24.28 "	33.84 "	" 29.06 "
" III	24.43 "	43.85 "	" 34.14 "
" IV	17.00 "	26.86 "	" 21.93 "
" V	17.45 "	26.10 "	" 21.77 "
" VI	29.59 "	47.35 "	" 38.47 "
" VII	15.33 "	23.82 "	" 19.57 "

The differences in their power of ammonification as exhibited by the several soils seem to bear no direct relation to their mechanical composition. Thus the clay loam soil from the asparagus field shows a comparatively high power, whereas the heavy clay soil from Matawan shows a lower power of ammonification. Again, soil IV., a dark-colored clay loam from Princeton, has about the same power of ammonification as soil V., a reddish sandy loam from Clarksville. Soil VI., a dark-colored sandy loam from Marlboro, shows the highest ammonification coefficient, while soil VII., a reddish, fine-grained, sandy soil from Freehold, shows the lowest ammonification coefficient. Quantitatively the differences are quite considerable, as, for instance, in the case of soils VI. and VII., which produced 47.35 mg. and 23.82 mg., respectively, of ammonia-nitrogen at the end of the four-day period.

Peptone Salt + 20 cc. Infusion.

	In 3 Days.	In 4 Days.	
Soil Infusion I	55.08 mg.	78.00 mg.	Av. 66.54 mg.
" " II	57.65 "	79.52 "	" 68.59 "
" " III	42.79 "	71.17 "	" 56.98 "
" " IV	32.78 "	52.05 "	" 42.41 "
" " V	29.59 "	57.51 "	" 43.55 "
" " VI	48.26 "	69.15 "	" 58.70 "
" " VII	20.64 "	49.47 "	" 35.05 "

Leaving out of consideration the inoculations with infusion ., as not strictly comparable with the rest, since non-sterile stilled water was used here for the preparation of the infusions, find relations similar to those noted in the preceding group. ıe addition of the mineral salts to the peptone favored the de- lopment of the ammonification bacteria, but was not capable materially modifying the deep-seated bacteriological differ- ces. As in the direct soil inoculations, we note here the high ımonification coefficients of soils I. and VI., the practical uality of the ammonification coefficients of soils IV. and V., d the comparatively low ammonification coefficient of soil VII.

Peptone. Ten Grams Soil, Sterile. Corresponding Infusion.

		In 3 Days.	In 4 Days.	
Soil	I	33.99 mg.	51.29 mg.	Av. 42.64 mg.
"	II	31.71 "	44.01 "	" 37.86 "
"	III	32.17 "	52.35 "	" 42.26 "
"	IV	16.39 "	25.19 "	" 20.79 "
"	V	18.21 "	27.31 "	" 22.76 "
"	VI	35.36 "	48.56 "	" 41.96 "
"	VII	14.87 "	27.31 "	" 21.09 "

Differences similar to those brought out in the direct soil in- ılations are apparent also here. Soils I. and VI. show the ghest power of ammonification among the several soils. Soils ., V. and VII. show a low ammonifying power, notably soil I., at the end of the three-day period. Soil III., which in the rect soil inoculation was slightly inferior to soils I. and VI., ıkes a better showing in the present group. In fact, at the end the four-day period it showed the highest ammonification co- icient of any of the soils. On the whole, this group indi- es that in the seven different soils employed, all, or nearly , of the bacteria in the soil can be brought into suspension by ive-minute agitation in water, and that the soil infusions thus oduced compare favorably in their ammonifying power with uivalent quantities of soil used directly. There is even a ıdency here towards a higher ammonification coefficient for infusions as compared with the soils used directly.

Peptone. The Same Soil, Sterile. Different Infusion.

		In 3 Days.	In 4 Days.	
Soil I., Infusion	I	35.81 mg.	49.92 mg.	Av. 42.86 mg.
" I., "	II	34.90 "	49.17 "	" 42.03 "
" I., "	III	34.90 "	49.77 "	" 42.33 "
" I, "	IV	21.70 "	33.38 "	" 27.54 "
" I., "	V	25.34 "	38.39 "	" 31.86 "
" I., "	VI	33.23 "	50.53 "	" 41.88 "
" I., "	VII	16.24 "	33.23 "	" 24.73 "

The bacteriological differences brought out by the direct soil inoculations, as well as by the inoculations with sterile soil, and corresponding infusion, are apparent also in the above group with the difference that the chemical factor—that is, the composition of the soil—has modified somewhat the course of ammonification. That is more clearly apparent in the inoculations with soil infusions IV., V. and VII. The sterile soil employed here evidently stimulated ammonification by these infusions, resulting in a higher ammonification coefficient. On the other hand, the ammonification coefficient in soils I., III. and VI. remained practically the same. It is also apparent from the above that, perceptible as is the influence of the chemical factor in ammonification, it is much slighter than that of the bacteriological factor. Notwithstanding the favorable influence of the sterile soil I., the ammonification coefficient of infusion VII., at the end of the three-day period, was only 16.24 mg. as against an ammonification coefficient of 35.81 mg. for the same soil inoculated with the corresponding infusion.

Peptone. Different Soil. The Same Infusion.

		In 3 Days.	In 4 Days.	
Soil I., Infusion	I	34.14 mg.	49.32 mg.	Av. 41.73 mg.
" II., "	I	36.72 "	55.24 "	" 45.98 "
" III., "	I	35.21 "	57.36 "	" 46.28 "
" IV., "	I	33.23 "	47.04 "	" 40.13 "
" V., "	I	37.33 "	54.17 "	" 45.75 "
" VI., "	I	36.27 "	51.75 "	" 44.01 "
" VII., "	I	34.60 "	52.05 "	" 43.32 "

With the soil infusion as the constant, and the soil itself as the variable factor, we are enabled to compare in the above group the changes in ammonification as affected by the chemical composition of the soil. We find in this comparison a perceptible, yet not extensive, modification as due to the chemical factor. Thus we note that with soils II., III., V., VI. and VII., as a basis, the infusion from soil I. showed a higher ammonification coefficient than it did in the presence of soil I. Taking it all in all, we find but a small difference here between the maximum and minimum ammonification in the several soils, namely, 46.28 mg.–40.13 mg. = 6.15 mg. Where, on the other hand, the bacteriological factor is made the variable, and the chemical factor the constant, as was done in the preceding group, the range of difference becomes much greater, namely, 42.86 mg.–24.73 mg. = 18.13, or almost three times as great as in the case of the chemical factor.

Series V.

In order to test further the purely chemical influences of the soil in the ammonification of peptone nitrogen, a number of peptone solutions, containing varying quantities of sterile soil were inoculated with a measured quantity of the same soil infusion. The following soils were employed:

Soil 1. Sandy loam used in box experiments.[1]
" 2. Clay loam used in cylinder experiments.[2]
" 3. Clay loam from College Farm.
" 4. Sandy soil from Vineland.
" 5. Clay loam soil from Freehold.
" 6. Heavy clay soil from Woodstown.

Each culture contained 100 cc. peptone, to which there was added the corresponding amount of the air-dry soil ground to pass a .5 mm. sieve. After sterilization in the autoclave, and cooling, the several culture solutions were each inoculated with 10 cc. infusion of a sandy loam soil from Matawan. This amount of infusion was equivalent to 5 gms. of moist soil. After standing at room temperature for three days, these cultures were analysed for ammonia in the usual manner.

[1] See Bull. 180, N. J. Agric. Exper. Station.
[2] See N. J. Stat. Rep., 1899, p. 97.

Scheme of Inoculation.

Culture No.	No soil. 10 cc. soil infusion.	Culture No.	1 gm. soil, sterile, 10 cc. soil infusion.	Culture No.	3 gms. soil, sterile, 10 cc. soil infusion.	Culture No.	5 gms. soil, sterile, 10 cc. soil infusion.
				100 cc. Peptone.			
1, 2.....	....	3	Soil I........	4......	Soil I	5.....	Soil I.
....	....	6......	" II.......	7.....	" II......	....	" II.
....	....	9......	" III.......	10......	" III.......	11......	" III
....	....	12......	" IV........	13......	" IV.......	14.....	" IV.
....	....	15.....	" V.......	16.....	" V........	17......	" V.
....	....	18......	" VI	19......	" VI......	20.....	" VI.
				100 cc. Peptone Salt.			
21 ..	....	22 ...	Soil VI........	23 ...	Soil VI.......	24	Soil VI.

Ammonia-Nitrogen Found in Three Days.

Peptone Solutions.

	No soil.	1 gm. soil.	3 gms. soil.	5 gms. soil.	
Soil I........	....	9.03 mg.	10.45 mg.	10.73 mg.	Av. 10.07 m
" II........	....	9.74 "	10.10 "	9.21 "	" 9.68 "
" III........	....	9.74 "	10.73 "	11.80 "	" 10.76 "
" IV........	....	6.38 "	8.15 "	8.86 "	" 7.80 "
" V........	....	9.03 "	10.27 "	10.73 "	" 10.01 "
" VI........	....	8.15 "	9.03 "	9.39 "	" 8.86 "
No soil.........	8.15 mg.	......	......	......	......
"	7.79 "	......	......	......	" 7.97 "
		Peptone Salt Solutions.			
Soil VI...	7.79 mg.	11.16 mg.	13 99 mg.	14.70 mg.	Av. 13.28 m

As already stated above, each of these cultures were inoculate after sterilization with 10 cc. of soil infusion equivalent to gms. of fresh soil.

An examination of the above data will show that the larger mounts of sterile soil made possible in nearly every case a arger yield of ammonia-nitrogen. In cultures 1 and 2, where o soil was present there was produced 8.15 mg. and 7.79 mg., espectively, of ammonia-nitrogen. The addition of 1, 2 and 5 rams, respectively, of soil I. led to a gradual increase, the yields eing 9.03 mg., 10.45 mg. and 10.74 mg. in the order named. similar increase is noted in all of the other soils, the only xception occurring in the case of soil II., where in the presence f 5 grams of soil the production of ammonia was less than that n the corresponding culture with 1 gram of soil. Differences are lso apparent in the influence on ammonification by the different oils. In comparing the average yields for each, we find the argest yield in the presence of soil III., a clay loam from the ollege Farm, and the smallest yield in the presence of soil IV., very light, sandy soil from Vineland. We find, on the other and, that in the presence of soil I., a sandy loam, there was an verage yield of 10.07 mg. of ammonia-nitrogen, whereas in the resence in soil VI., a heavy clay, the average yield was only .86 mg. of ammonia-nitrogen. Where peptone salt, instead of he peptone solution was used the process of ammonification was nfluenced more markedly by the presence of soil VI., for we ind that in the inoculation with soil infusion alone there was roduced in the peptone salt solution 7.79 mg. of ammonia-itrogen, while in the presence of soil the average production f ammonia-nitrogen was 13.28 mg. It may be claimed, of course, hat the increased production of ammonia-nitrogen in the presence f soil was due to the ammonification of the soil nitrogen. When e consider, however, that the nitrogen content of these soils anges from .10 per cent. to .18 per cent., which would give a ninimum nitrogen content of 5 mg., and a maximum nitrogen ontent of 9 mg., where the 5-gram quantities of soil were used, nd that hardly as much as 10 per cent. of this soil nitrogen will e ammonified in the three days, it becomes apparent that the ifferences in the yields of ammonia-nitrogen are due to some ther cause or causes. Of such causes there are two that suggest hemselves as a possible explanation of the variations in ques-

tion. It is possible or even probable that with the increasing quantities of soil there are introduced in the culture media certain amounts of mineral substances part of which become soluble in the decaying solutions. These dissolved mineral matters exert a stimulating effect on the activities of the ammonification bacteria. It is possible likewise that some of the products formed from the peptone, without or within the bacterial cells reacting injuriously on the bacteria themselves when accumulated in larger amounts, are absorbed by the soil, and that the conditions are thereby rendered more favorable for the rapid development of the organism. But whether the first or second of these explanations, or both together, would account for the differences noted, the influences in question should be traced back to the chemical, or physico-chemical differences in the constitution of the soils.

Series VI.

The culture solutions of the preceding series were inoculated with soil infusion. The culture solutions of the present series were inoculated with a pure culture of B. mycoides. Otherwise, the two series were similar in that they were intended to bring out the influence of different soils, used in varying quantities, on the progress of ammonification in peptone solutions. Distilled water, instead of tap-water, was used for the solution of the peptone. The following soils were employed in this series:

Soil 1. Clay loam soil.
" 2. Red shale, clay loam soil.
" 3. Sand loam soil.
" 4. Sandy soil.
" 5. Heavy clay soil.
" 6. Red shale, clay loam soil, cylinder soil 1.*
" 7. " " " " " 2.
" 8. " " " " " 3.

The quantities of soil used in each group were 50 mg., 100 mg., 300 mg., 1 gm., 2 gms. and 5 gms., respectively. As in the preceding series, all of the soils employed were in air-dry condition, and ground to pass .5 mm. sieve. After the addition

* See N. J. Stat. Rep., 1905, p. 138.

of the corresponding amounts of soil to the peptone solutions, the culture flasks were placed in the autoclave, sterilized at a pressure of 1.75 atmospheres, cooled, and inoculated with a pure culture of B. mycoides.

Scheme of Inoculation.

Culture No.	100 cc. peptone, 50 mg. soil, sterile, B. mycoides.	Culture No.	100 cc. peptone, 100 mg. soil, sterile, B. mycoides.	Culture No.	100 cc. peptone, 300 mg. soil, sterile, B. mycoides.	Culture No.	100 cc. peptone, 1 gm. soil, sterile, B. mycoides.	Culture No.	100 cc. peptone, 2 gms. soil, sterile, B. mycoides.	Culture No.	100 cc. peptone, 5 gms. soil, sterile, B. mycoides.
1	Soil I.	2	Soil I.	3	Soil I.	4	Soil I.	5	Soil I.	6	Soil I.
7	" II.	8	" II.	9	" II.	10	" II.	11	" II.	12	" II.
13	" III.	14	" III.	15	" III.	16	" III.	17	" III.	18	" III.
19	" IV.	20	" IV.	21	" IV.	22	" IV.	23	" IV.	24	" IV.
25	" V.	26	" V.	27	" V.	28	" V.	29	" V.	30	" V.
31	" VI.	32	" VI.	33	" VI.	34	" VI.	35	" VI.	36	" VI.
37	" VII.	38	" VII.	39	" VII.	40	" VII.	41	" VII.	42	" VII.
43	" VIII.	44	" VIII.	45	" VIII.	46	" VIII.	47	" VIII.	48	" VIII.

The amounts of ammonia-nitrogen found in the several cultures were as follows:

Ammonification by B. Mycoides in Presence of Soil 1.
In 10 Days.

Culture No.			Culture No.		
1	5.64 mg.	6.40 mg.	4	6.88 mg.	8.05 mg.
2	5.11 "		5	8.11 "	
3	8.46 "		6	9.17 "	

The above results are rather irregular and fail to show any definite increase in ammonification as due to the varying quantities of soil used. There is a larger average yield, however, in cultures 4 to 6, where the larger quantities of soil were employed, as compared with the average yield in cultures 1 to 3.

Ammonification by B. Mycoides in Presence of Soil 2. In 10 Days.

Culture No.			Culture No.		
7	8.99 mg.	7.46 mg.	10	7.76 mg.	7.82 mg.
8	7.23 "		11	6.52 "	
9	6.17 "		12	9.17 "	

The results are irregular, also, in the above group, with a sin lar tendency towards a higher ammonification coefficient in tl presence of the larger quantities of soil.

Ammonification by B. Mycoides in Presence of Soil 3. In 17 Days.

Culture No.			Culture No.		
13	12.93 mg.	18.09 mg.	16	25.53 mg.	27.00 mg.
14	19.57 "		17	26.55 "	
15	21.78 "		18	28.93 "	

The above group of inoculations shows a gradually increasi ammonification coefficient with the increasing amount of s added. The greatest increase occurs between cultures 13 and 1 containing respectively 50 and 100 mg. of soil. Taking tl average yields of ammonia-nitrogen of cultures 13 to 15, a cultures 16 to 18, respectively, we find an increase of almost per cent. in the second of these groups.

Ammonification by B. Mycoides in Presence of Soil 4. In 17 Days.

Culture No.			Culture No.		
19	19.40 mg.	17.76 mg.	22	21.78 mg.	24.97 mg.
20	18.55 "		23	24.02 "	
21	15.32 "		24	29.10 "	

The results in the above group are irregular, showing a pı gressive decrease from cultures 19 to 20, and a progressive i crease from 22 to 24. On the whole, however, we again find

markedly larger yield of ammonia-nitrogen in the presence of the larger quantities of soils.

Ammonification by B. Mycoides in Presence of Soil 5. In 19 Days.

Culture No.			Culture No.		
25	21.61 mg.	19.57 mg.	28	24.34 mg.	21.90 mg.
26	20.42 "		29	21.61 "	
27	16.68 "		30	19.74 "	

Ammonification by B. Mycoides in Presence of Soil 6. In 19 Days.

Culture No.			Culture No.		
31	21.78 mg.	25.07 mg.	34	21.44 mg.	24.51 mg.
32	26.89 "		35	34.21 "	
33	26.55 "		36	17.87 "	

The returns for soils 5 and 6 are even less satisfactory than the others. There was a progressive decrease in cultures 25 to 27, and also cultures 28 to 30. In the case of soil 6, we note a large production of ammonia in culture 35, and a comparatively small yield in culture 36.

Ammonification by B. Mycoides in Presence of Soil 7. In 19 Days.

Culture No.			Culture No.		
37	23.15 mg.	25.19 mg.	40	30.64 mg.	26.84 mg.
38	26.72 "		41	23.49 "	
39	25.70 "		42	26 38 "	

Ammonification by B. Mycoides in Presence of Soil 8. In 19 Days.

Culture No.			Culture No.		
43	26.21 mg.	29.50 mg.	46	27.74 mg.	35.97 mg.
44	30.64 "		47	40.17 "	

Notwithstanding the irregular results also in the case of soil 7 and 8, there are at least two facts of interest to be noted in th two groups of cultures. It will be observed that the average yield of ammonia in each group were greater where the larger quanti ties of soil were used. This is true of all of the groups, with th exception of that of soil 6. It will be observed, likewise, that th ammonification coefficient of soil group 8 is higher than that o soil group 7, and the latter in its turn higher than that o soil group 6. The interesting point in this connection is tha soils 6, 7 and 8 are all of the same origin and correspond with cylinder soils 1, 2 and 3. They have been differentiated, how ever, by fertilizer treatment. Soil 6 has been cropped for th past nine years without application of manure or fertilizer; soi 7 has been receiving annual applications of acid phosphate and of muriate of potash, while soil 8 has been receiving, in additior to the phosphate and of muriate annual dressings of cow manure a the rate of about sixteen tons per acre. The differences thus intro duced undoubtedly find expression in the ammonification coeffi cients of these soils in the presence of a pure culture of B. myco ides. Yet, on the whole, the results are quite irregular and un satisfactory, and it would seem that the discrepancies are du to the difficulty, in the inoculations with slight quantities o culture, of introducing into the solution inoculated, bacteria cells, that are qualitatively and quantitatively equivalent. This belief is strengthened by the fact that two similar peptone solu tions to which no soil at all had been added, and which were similarly inoculated with B. mycoides yielded at the end of 19 days 35.74 mg. and 17.71 mg., respectively, of ammonia-nitrogen Such a wide divergence of results with apparently the same in oculation into solutions of exactly the same nature, helps to ex plain the difficulty of securing concordant data. On the other hand, the soil infusion used for similar inoculations in the pre ceding series gave returns that were on the whole concordant It is quite likely at the same time, that with modifications in the constitution of the culture medium, concordant results will be secured also with pure cultures of B. mycoides or of other soil bacteria.

Series VII.

The experiment described above indicated the desirability of inding some nitrogenous substance other than peptone that ould decompose less rapidly on inoculation with soil or soil in-usion, and would still yield concordant results. It was decided, herefore, to try, among other things, a 1 per cent. solution of elatin. The gelatin culture medium as employed in the pres-nt series was made up as follows:

10 gms. gelatin.
.1 " K_2HPO_4.
.1 " $MgSO_4$.
.01 " $CaCl_2$.
1 drop $FeCl_3$ solution.
1000 cc. distilled water.

Both soil and soil infusion were used for inoculation in the nanner indicated in the preceding series. Where the soil itself as used there were 20 cc. of water added before sterilization to he 100 cc. of the culture solution, so as to make the total volume 20 cc., as in the case of the inoculations with soil infusion. The noculating material consisted of asparagus soil samples secured ur months previously, and kept in stoppered jars in the labora-ory, and likewise of fresh samples of the same soil.

Scheme of Inoculation.

	Old Samples.			New Samples.		
	100 cc. gelatin, 20 cc. infusion, soil I.	100 cc. gelatin, 20 cc. infusion, soil II.	100 cc. gelatin, 20 cc. infusion, soil III.	100 cc. gelatin, 20 cc. infusion, soil I.	100 cc. gelatin, 20 cc. infusion, soil II.	100 cc. gelatin, 20 cc. infusion, soil III.
ulture Nos.	1, 2, 3, 4	5, 6, 7, 8	9, 10, 11, 12	13, 14, 15, 16	17, 18, 19, 20	21, 22, 23, 24
With Soil Instead of Infusion Used for Inoculation.						
ulture Nos.	25, 26, 27, 28	29, 30, 31, 32	33, 34, 35, 36	37, 38, 39, 40	41, 42, 43, 44	45, 46, 47, 48

Culture solutions 49 and 50 were both kept sterile, the former ontaining 100 cc. gelatin; the latter 100 cc. gelatin and 20 cc. ap-water.

Ammonia-Nitrogen in the Soil-Infusion Inoculation.

Old Samples.

	In 3 Days.		In 5 Days.	
Soil Infusion I....	20.88 mg.		80.49 mg.	
" " I...	17.85 "	Av. 19.36 mg.	73.76 "	Av. 77.12 mg.
" " II...	13.81 "		81.84 "	
" " II...	18.69 "	" 16.25 "	68.87 "	" 75.35 "
" " III...	20.71 "		79.82 "	
" " III...	21.89 "	" 21.30 "	72.07 "	" 75.94 "

New Samples.

	In 3 Days.		In 5 Days.	
Soil Infusion I...	27.45 mg.		91.94 mg.	
" " I...	29.13 "	Av. 28.29 mg.	94.30 "	Av. 93.12 mg.
" " II...	25.93 "		76 96 "	
" " II...	23.40 "	" 24.66 "	79.65 "	" 78.30 "
" " III...	28.96 "		95.99 "	
" " III...	30.48 "	" 29.72 "	95.48 "	" 95.73 "

The agreement in the parallels of the first of the above groups is not very satisfactory. Thus, at the end of the three-day period there is a difference in the parallels of soil infusion I. of about 3 mg., and of soil infusion II. of almost 5 mg. of ammonia-nitrogen. At the end of the five-day period, the differences were larger, reaching a maximum in the case of soil infusion II. of almost 13 mg. Apart from these differences, we find the highest ammonification coefficient in the case of infusion III. at the end of the three-day period, and in the case of infusion I. at the end of the five-day period. We note, likewise, that soil infusion II. showed the lowest ammonification coefficient.

The agreement in the parallels of group two is decidedly more satisfactory, the maximum differences not exceeding in any case two and one-half milligrams of ammonia-nitrogen at the end of the three-day period. Similarly at the end of the five-day period the maximum variation was less than three milligrams. It appears thus, that the bacterial character of the old samples of the asparagus soils had changed considerably insofar at least as their power of leading to more or less uniform ammonification was concerned. The two sets of samples agree none the less in showing a distinctly smaller ammonification coefficient for soil II. than for either of the other soils. Thus, at the end of the three-

day period, there was produced, in the case of soil infusion II., 24.66 mg. of ammonia-nitrogen, as against 28.92 mg. for soil infusion I., and of 29.72 mg. for soil infusion III. At the end of the five-day period there was produced 78.30 mg. of ammonia-nitrogen in the case of soil infusion II., and 93.12 mg. and 95.73 mg., respectively, for soil infusions I. and III. It may safely be concluded, therefore, the different fertilizer treatment has markedly affected the ammonifying power of soil II., and that the annual additions of bone and potash to the complete fertilizer applied to soil II. have no less markedly affected the ammonifying power of soil III. Another point to be noted here is the decidedly greater ammonifying power of the fresh samples, although it is uncertain how much of this difference should be ascribed to the modifications in the older samples, due to their standing in the laboratory, and how much of it to the initial bacteriological differences in the samples themselves.

Ammonia-Nitrogen in the Soil Inoculations.

Old Samples.

	In 3 Days.		In 5 Days.	
Soil I.....	23.74 mg.		87.0 mg.	
" I.....	25.59 "	Av. 24 66 mg.	87.17 "	Av. 87.08 mg.
" II.....	19.20 "		76.45 "	
" II.....	24.08 "	" 21.64 "	76.28 "	" 76 36 "
" III.....	23.57 "		82.52 "	
" III.....	24.92 "	" 24.24 "	62.98 "	" 72.75 "

New Samples.

	In 3 Days.		In 5 Days.	
Soil I.....	31.16 mg.		93.29 mg.	
" I.....	30.82 "	Av. 30.99 mg.	94.98 "	Av. 94.13 mg.
" II.....	32.67 "		88.58 "	
" II.....	27.28 "	" 29.97 "	86.49 "	" 87.53 "
" III.....	31.50 "		97.50 "	
" III.....	33.01 "	" 32.25 "	88.75 "	" 93.12 "

The agreement in the parallel inoculations of the first of the above two groups is, on the whole, much better than that in the corresponding soil-infusion inoculations. The greatest variation here, at the end of the three-day period, was somewhat less than 5 mg., while at the end of the five-day period the variations in soils I.

and II. were less than 1 mg. On the other hand, the variation in soil III. was more than 19 mg. and rather abnormal. We again note here the slighter ammonification coefficient of soil II. at the end of the three-day period, and also of the five-day period, if we exclude the last culture in this group, already designated as rather abnormal, that is, as showing a variation greater than might be expected under the circumstances.

The greatest variation in the second of the above two groups occurs in soil II., and amounts to somewhat more than 5 mg. at the end of the three-day period, and to less than 9 mg. at the end of the five-day period. Also here we note the lower ammonification power of soil II. both at the end of the three and five-day periods. We thus find that, under the conditions of the experiment, the bacteriological differences developed in initially identical soil, by varying fertilizer treatment are brought out clearly and consistently, whether soil infusion or the soil itself is used as inoculating material. We find, furthermore, that these bacteriological differences in the soils were not obliterated entirely even after keeping the samples in the laboratory for months, although the long period of this artificial environment had undoubtedly produced deep-seated changes.

We find again, as in the case of the soil infusions, that the new samples were much superior to the old in their power of ammonification, and likewise, that the direct soil inoculations have led to the production of more ammonia in the culture solution, than was true of the corresponding soil-infusion inoculations.

Series VIII.

The ammonification coefficients of the old and new samples of the asparagus soils were further compared in the present series. The culture solutions used here were: *a.* Gelatin, containing 10 gms. of gelatin, .1 gm. K_2HPO_4, .1 gm. $MgSO_4$ per liter of tap-water; *b.* peptone, like *a*, but containing 10 gms. of Witte's peptone, instead of the gelatin per liter of tap-water; *c.* gelatin, like *a*, but rendered slightly alkaline to phenolphthalein by the addition of sodium hydrate. The three solutions are designated here as gelatin, peptone and alkaline gelatin, respectively. The

soil itself was used for inoculation in each instance; the solutions were prepared, distributed in the flasks, and sterilized in the customary manner.

Scheme of Inoculation.

Gelatin Solution.

	Old Samples.			New Samples.		
	100 cc. culture solution, 10 gms. Asparagus soil I.	100 cc. culture solution, 10 gms. Asparagus soil II.	100 cc. culture solution, 10 gms. Asparagus soil III.	100 cc. culture solution, 10 gms. Asparagus soil I.	100 cc. culture solution, 10 gms. Asparagus soil II.	100 cc. culture solution, 10 gms. Asparagus soil III.
Culture No.	1, 2	3, 4	5, 6	7, 8	9, 10	11, 12

Alkaline Gelatin Solution.

Culture No.	13, 14	15, 16	17, 18	19, 20	21, 22	23, 24

Peptone Solution.

Culture No.	25, 26	27, 28	29, 30	31, 32	33, 34	35, 36

Ammonia determinations were made in the usual way at the end of four days, and the following amounts of nitrogen found:

Ammonia-Nitrogen in Gelatin.

	Old Samples.		New Samples.	
Asparagus soil I......	41.59 mg.		42.60 mg.	
" " I......	40.74 "	Av. 41.16 mg.	46.15 "	Av. 44.37 mg.
" " II......	33.81 "		39.05 "	
" " II......	38.71 "	" 36.26 "	45.64 "	" 42 34 "
" " III......	38.37 "		56.12 "	
" " III......	44.46 "	" 41.41 "	55.95 "	" 56.03 "

As in series VII. we find here the ammonification coefficient of soil II. smaller than that of either soil I. or soil II. This is true of both the old and the new samples. It will be seen likewise, that the ammonifying power of the new samples was in every instance superior to that of the corresponding old samples.

Ammonia-Nitrogen in Alkaline Gelatin.

		Old Samples.		New Samples.	
Asparagus soil	I......	46.83 mg.		51.56 mg.	
" "	I......	49.87 "	Av. 48.35 mg.	58.15 "	Av. 54.85 mg.
" "	II......	41.93 "		42.10 "	
" "	II......	43.11 "	" 42.52 "	45.81 "	" 43.95 "
" "	III......	38.88 "		58.83 "	
" "	III.....	51.05 "	" 44.96 "	64.75 "	" 61.79 "

The addition of sodium hydrate to the solution of gelatin had evidently favored the production of ammonia in the culture medium, as may be seen from a comparison of the two sets of cultures. Once more we find a smaller ammonification coefficient for soil II. than for either of the other soils, and likewise a greater ammonifying power in the new samples as compared with the old samples. It should be added here that there was an interval of about an hour and a half in the analysis of the parallels in each set, hence the greater quantity of ammonia in most of the second determinations.

Ammonia-Nitrogen in Peptone.

		Old Samples.		New Samples.	
Asparagus soil	I.....	100.75 mg.		98.05 mg.	
" "	I.....	96.70 "	Av. 98.72 mg.	99.01 "	Av. 98.53 mg.
" "	II.....	90.44 "		94.84 "	
" "	II.....	98.05 "	" 94.24 "	98.22 "	" 96.53 "
" "	III.....	92.98 "		99.40 "	
" "	III.....	98.56 "	" 95.72 "	101.43 "	" 100.41 "

The production of ammonia in the peptone solutions was more extensive than in either of the gelatin solutions. In fact the ammonification in the peptone solutions had progressed far enough to convert most of the albumose, peptone and amine nitrogen into ammonia. Notwithstanding this far-reaching change, the inferior ammonifying power of soil II. is still apparent, both in the old and new samples, while the latter still retain their superiority over the old samples. On the whole, the gelatin solutions proved more satisfactory than the peptone solutions, bringing out the differences indicated, thanks, partly, to their less rapid decomposition when inoculated with soil or soil infusion.

Series IX.

The ammonification studies on the asparagus soils demonstrated that the differentiation of initially similar soils, as affected by different fertilizer treatment, may be detected in certain of their bacteriological reactions. It became interesting to determine, therefore, whether similar differences would be brought out by treating in the laboratory portions of the same soil with varying quantities of lime. Accordingly, a quantity of soil, of the type designated as Penn Stony Loam, by the Bureau of Soils, was collected with the usual precautions against contamination, and taken to the laboratory. It was thoroughly mixed on the following day, and all of the pebbles were removed. It was then divided into five equal portions, to four of which there was added calcium carbonate at the rate of .5 ton, one ton, two tons and three tons, respectively, per acre. The fifth portion received no lime at all. The lime was in each case thoroughly mixed with the soil in a sterile dish, and was then returned to the corresponding glass jar. A day after the admixture of the lime, the soil was used for inoculation as described in the scheme of inoculation. Direct soil inoculations were made in each case, and, as in the preceding series, 10 gms. of soil were added to the 100 cc. of sterile culture solution. Similar portions of the culture solutions which were sterilized after the addition of the corresponding soils were inoculated with a pure culture of B. mycoides. The culture solutions were either *gelatin* or *peptone*, and were prepared as described in series VIII. Ammonia was determined in the soil inoculations at the end of four days, and in the B. mycoides inoculations at the end of six days.

Scheme of Inoculation.

Gelatin Solution.

	100 cc. culture solution, 10 gms. soil I.	100 cc. culture solution, 10 gms. soil II.	100 cc. culture solution, 10 gms. soil III.	100 cc. culture solution, 10 gms. soil IV.	100 cc. culture solution, 10 gms. soil V.	100 cc. culture solution, 10 gms. soil I., sterile, B. mycoides.	100 cc. culture solution, 10 gms. soil II., sterile, B. mycoides.	100 cc. culture solution, 10 gms. soil III., sterile, B. mycoides.	100 cc. culture solution, 10 gms. soil IV., sterile, B. mycoides.	100 cc. culture solution, 10 gms. soil V., sterile, B. mycoides.
Culture No.	1, 2	3, 4	5, 6	7, 8	9, 10	11, 12	13, 14	15, 16	17, 18	19, 20

Peptone Solution.

Culture No.	21, 22	23, 24	25, 26	27, 28	29, 30	31, 32	33, 34	35, 36	37, 38	39, 40

The soils numbered from I. to V. received the following treatment:

I. No lime.
II. .5 ton of calcium carbonate per acre.
III. 1 ton " " " " "
IV. 2 tons " " " " "
V. 3 tons " " " " "

The several cultures which were kept at room temperature yielded the following amounts on ammonia-nitrogen:

Soil Inoculations.

Ammonia-Nitrogen in the Culture Solutions.

	Gelatin.		Peptone.	
Soil I......	43.78 mg.		91.79 mg.	
" I......	46.66 "	Av. 45.22 mg.	89.60 "	Av. 90.69 mg.
" II......	54.77 "		90.61 "	
" II......	50.38 "	" 52.57 "	92.30 "	" 91.45 "
" III......	54.77 "		93.93 "	
" III......	60.01 "	" 57.39 "	93.48 "	" 93.70 "
" IV......	58.15 "		96.53 "	
" IV......	61.53 "	" 59.84 "	93.15 "	" 94.84 "
" V......	61.20 "		97.03 "	
" V......	56.12 "	" 58.66 "	96.86 "	" 96.94 "

Comparing the amounts of ammonia-nitrogen found in the gelatin cultures, we note at once that the addition of lime to the soil has produced a marked effect. The decay bacteria were evidently stimulated in their development, and probably also in their physiological efficiency, by the presence of lime. We thus note that the average yield of ammonia-nitrogen was 45.22 mg., where no lime was added to the soil; 52.57 mg., where lime was added at the rate of .5 ton per acre; 57.39 mg., where lime was added at the rate of one ton per acre; 59.84 mg., where lime was added at the rate of two tons per acre, and 58.66 mg., where lime was added at the rate of three tons per acre. There was thus a gradually increasing production of ammonia, with the increasing amount of lime up to additions of two tons per acre. Beyond that there was no further increase.

Also, in the peptone solutions, there was an increase in the amounts of ammonia produced as the amounts of calcium carbonate added became greater. The distinctions are not as sharp here as they are in the gelatin solutions, yet they serve to strengthen the conclusions reached above. There is no doubt that the breaking down of the nitrogenous substances in the culture media was favored by the presence of lime, and the results indicated here receive an added interest from the fact that there is still a difference of opinion as to the effect of lime on the transformations of soil nitrogen. It seems probable that in making use of the method, or its modifications, as outlined here, we shall be enabled to develop an accurate and delicate method for the measure of the lime requirement of soils, and possibly also of the magnesia, phosphorus and potassium requirement of soils. At any rate, these and the additional data reported in the following pages show the desirability of further study along the lines indicated. Much time and work is still needed for the investigation of various culture media as to their adaptability to this purpose, and of the errors and limitations of the method under varying conditions of soil and temperature.

B. Mycoides Inoculations.

Ammonia-Nitrogen in the Culture Solutions.

		Gelatin.		Peptone.	
Soil	I......	4.73 mg.		9.80 mg.	
"	I......	4.23 "	Av. 4.48 mg.	10.48 "	Av. 10.14 mg.
"	II......	5.41 "		11.83 "	
"	II......	4.06 "	" 4.73 "	6.59 "	" 9.21 "
"	III......	5.75 "		8.62 "	
"	III......	2.20 "	" 3.97 "	8.11 "	" 8.36 "
"	IV......	7.38 "		7.27 "	
"	IV......	3.72 "	" 5.55 "	7.10 "	" 7.18 "
"	V......	5.75 "		15.38 "	
"	V......	3.72 "	" 4.73 "	10.48 "	" 12.93 "

It will be seen at a glance that in the above table the yields ammonia-nitrogen were larger in the peptone than they were the gelatin solutions. Otherwise, the results are so irregula and the lack of agreement in the parallels so marked, that definite conclusion can be drawn as to the effect of lime in tl sterile soils on the ammonification of the gelatin or peptone nitr gen by B. mycoides. It was already noted in preceding seri that the quantitative and qualitative differences existing in t small amounts of the B. mycoides culture used for inoculati are sufficiently great to more than offset any differences in t sterile soils present in the culture solutions. It is quite possib however, that larger quantities of inoculating material wou yield concordant results in ammonification.

Series X.

After standing in the laboratory for eight days longer, the so used in series IX. were again employed for inoculation. Th were numbered as before: I., II., III., IV. and V., according their content of calcium carbonate, given in the preceding seri Both soil and soil infusion were used as inoculating material, latter having been secured by agitating 300 gms. of the cor sponding soil in 600 cc. of sterile tap-water. The inoculati were made into three solutions, viz., gelatin, alkaline gelat and peptone, prepared in the manner indicated above.

Scheme of Inoculation.

Gelatin Solution.

	100 cc. culture solution, 20 cc. tap-water, sterile, 10 gms. soil I.	100 cc. culture solution, 20 cc. tap-water, sterile, 10 gms. soil II.	100 cc. culture solution, 20 cc. tap-water, sterile, 10 gms. soil III.	100 cc. culture solution, 20 cc. tap-water, sterile, 10 gms. soil IV.	100 cc. culture solution, 20 cc. tap-water, sterile, 10 gms. soil V.	100 cc. culture solution, 20 cc. soil infusion I.	100 cc. culture solution, 20 cc. soil infusion II.	100 cc. culture solution, 20 cc. soil infusion III.	100 cc. culture solution, 20 cc. soil infusion IV.	100 cc. culture solution, 20 cc. soil infusion V.
lture No.	1, 2	3, 4	5, 6	7, 8	9, 10	11, 12	13, 14	15, 16	17, 18	19, 20

Alkaline Gelatin Solution.

lture No.	21, 22	23, 24	25, 26	27, 28	29, 30	31, 32	33, 34	35, 36	37, 38	39, 40

Peptone Solution.

ture No.	41, 42	43, 44	45, 46	47, 48	49, 50	51, 52	53, 54	55, 56	57, 58	59, 60

Ammonia determinations were made in each set of two rallels at the end of three days, and in the other at the end three and one-half days. This will account for the differces in the parallels and indicated in the following tabulations:

Ammonia-Nitrogen in the Gelatin Solutions.

	Soil.		Soil Infusion.	
Soil I......	10.95 mg.		11.28 mg.	
" I	14.22 "	Av. 12.58 mg.	17.82 "	Av. 14.55 mg.
" II......	16.19 "		13.57 "	
" II......	23.05 "	" 19.62 "	18.97 "	" 16.27 "
" III	14.06 "		16.35 "	
" III......	17.49 "	" 15.77 "	19.29 "	" 17.82 "
" IV......	16.84 "		18.15 "	
" IV......	19.29 "	" 18.06 "	19.95 "	" 19.05 "
" V......	19.46 "		17.98 "	
" V......	24.69 "	" 22.07 "	23.71 "	" 20.84 "

Taking the above yields of ammonia-nitrogen as due to the il inoculations, we perceive at once that the addition of lime to

the soil had markedly affected its ammonifying power, exceptin the yields as due to soil II. We note here a gradual increase ε the quantity of lime added grows larger. This is true of th amounts found at the end of both the three-day and the thre *and-one-half-day periods. The higher yields in soil inoculation* II. may be ascribed either to accidental variations as they som times occur in apparently identical cultures, or to the reaction c the culture medium favoring the predominance of certain ba terial groups.

Where soil infusion was used for inoculation, the results ar even more consistent. A gradual increase in the production c ammonia follows here the increased proportion of lime in th soil. Thus, while the amount of ammonia-nitrogen produced b the no lime soil infusion was 14.55 mg.; the correspondin amounts were 16.27 mg., 17.82 mg., 19.05 mg. and 20.84 mg. c ammonia-nitrogen for the soil infusion prepared from the soils t which lime was added at the rate of one-half ton, one ton, tw tons and three tons, respectively. Comparing the production ammonia by the soil and soil-infusion inoculations, respectivel we find that the latter caused, on the whole, a larger yield.

Ammonia-Nitrogen in the Alkaline Gelatin Solutions.

		Soil.		Soil Infusion.	
Soil	I......	17.82 mg.		15 20 mg.	
"	I......	19.29 "	Av. 18.55 mg.	17.82 "	Av. 16 51 mg.
"	II......	16.02 "		14.06 "	
"	II......	18 97 "	" 17.50 "	21.25 "	" 17.65 "
"	III......	16.35 "		14.39 "	
"	III	19.13 "	" 17.74 "	21.09 "	" 17.74 "
"	IV......	17.16 "		18.31 "	
"	IV......	21.58 "	" 19 37 "	20.27 "	" 19.29 "
"	V......	25.01 "		17.82 "	
"	V......	24.20 "	" 24.60 "	21.58 "	" 19.70 "

The soil inoculations in the alkaline gelatin solutions, like thos in the gelatin solutions, show the influence of the lime used. Th differences here are not as sharp, as was to be expected, and th yield of ammonia-nitrogen in the no lime inoculations wa greater than in the case of soils II. and III. for reasons alread

considered above. Where the alkaline gelatin solutions were inoculated with soil infusion, instead of soil, the yields of ammonia show likewise the influence of the lime added. There is a gradual increase in the amount of ammonia-nitrogen produced from 16.51 mg. to 19.70 mg. These differences, while quite apparent, are not as clear cut as they were in the gelatin solutions. Unlike the results in the latter, the soil-infusion inoculations did not produce a greater amount of ammonia-nitrogen than did the soil inoculations. In fact, there is a striking agreement here in the case of soils II., III. and IV., since the average production of ammonia-nitrogen in the soil inoculations was 17.50 mg., 17.74 mg., and 19.37 mg., as against 17.65 mg., 17.74 mg., and 19.29 mg., respectively, for the soil-infusion inoculations.

Ammonia-Nitrogen in the Peptone Solutions.

	Soil.		Soil Infusion.	
Soil I......	50.52 mg.		36.30 mg.	
" I......	51.67 "	Av. 51.09 mg.	44.80 "	Av. 40.55 mg.
" II......	42.84 "		47.90 "	
" II......	60.49 "	" 51.66 "	51.99 "	" 49.94 "
" III......	46.60 "		42.18 "	
" III	57.87 "	" 52.23 "	60.82 "	" 51.50 "
" IV......	43.49 "		59.84 "	
" IV......	56.57 "	" 50.03 "	58.70 "	" 59.27 "
" V......	55.26 "		57.88 "	
" V......	71.29 "	" 63.27 "	75.37 "	" 66.62 "

As in preceding series the production of ammonia with peptone solutions was greater than in the gelatine solutions. Where the soils were used for direct inoculation, the influence of the lime is not brought out as distinctly as was the case with the gelatin solutions. There is here, at the same time, an unmistakable difference that may be ascribed to the presence of the varying quantities of lime present in the soils. Thus, there was a slight increase in the average yield of ammonia-nitrogen from the inoculations with soil I. to those of soil III. Furthermore, there was a marked increase in the yield of ammonia-nitrogen in the case of soil V. as against the yield due to the other soils. On the other hand, the production of ammonia in the soil-infu-

sion inoculations was more in keeping with the results secured the gelatin solutions. There was a gradual increase from 40. mg. of ammonia-nitrogen to 66.62 mg. from soil I. to soil It must be assumed, therefore, that the more uniform and co sistent results secured from the use of the soil infusions as cor pared with the corresponding soils, was due to the greater ur formity in the character of the inoculating material. It wou seem that notwithstanding the most careful mixing of the sc used for inoculation, considerable difference between one anoth may still be manifested by the ten gram portions drawn fro the same sample. Where larger quantities of soil are used f the preparation of soil infusion, 300 to 1,000 gms., the inocul ting material may easily be rendered more uniform, thus assu ing greater uniformity in the progress of ammonification. the same time, it must be remembered that the influence of tl chemical factor is largely eliminated when soil infusion alone used, and hence the latter may not be adapted in all cases bring out soil differences. Further study will demonstra whether proper modification of the culture media employed he or elsewhere will allow the exclusive use of soil infusions for tl investigation of ammonification or other bacteriological process in the soil.

Series XI.

The present series consists of an attempt to differentiate in th soils of series X. the chemical and bacteriological factors co cerned in the ammonification of gelatin and peptone nitroge The solutions in question were prepared as in the precedin series. The same method was followed in the preparation the infusions, as well as in the inoculations of the culture of th culture solutions.

Scheme of Inoculation.

Gelatin Solutions.				Peptone Solutions.			
Culture No.	100 cc. culture solution, 10 gms. of different soil, sterile, 20 cc. of same infusion.	Culture No.	100 cc. culture solution, 10 gms. of same soil, sterile, 20 cc. different infusion.	Culture No.	100 cc. culture solution, 10 gms. of different soil, sterile, 20 cc. same infusion.	Culture No.	100 cc. culture solution, 10 gms. of same soil, sterile, 20 cc. different infusion.
1, 2	Soil I., Infusion I	11, 12	Soil I., Infusion I	21, 22	Soil I., Infusion I	31, 32	Soil V., Infusion I.
3, 4	" II., " I	13, 14	" I., " II	23, 24	" II., " I	33, 34	" V., " II.
5, 6	" III., " I	15, 16	" I., " III	25, 26	" III., " I	35, 36	" V., " III.
7, 8	" IV., " I	17, 18	" I., " IV	27, 28	" IV., " I	37, 38	" V., " IV.
9, 10	" V., " I	19, 20	" I., " V	29, 30	" V., " I	39, 40	" V., " V.

After standing at room temperature for three days, the several cultures were analysed, and the following amounts of ammonia-nitrogen found :

Ammonia-Nitrogen With Different Soils and Same Infusion.

			Gelatin.		Peptone.	
Soil	I., Infusion	I......	10.14 mg.		45.45 mg.	
"	I., "	I......	14.22 "	Av. 12.18 mg.	50.36 "	Av. 47.90 mg.
"	II., "	I......	12.75 "		44.63 "	
"	II., "	I......	14.06 "	" 13.40 "	59.19 "	" 51.91 "
"	III., "	I......	12.26 "		49.54 "	
"	III., "	I......	14.22 "	" 13.24 "	56.57 "	" 53.05 "
"	IV., "	I......	12.26 "		51.83 "	
"	IV., "	I......	15.70 "	" 13.96 "	54.44 "	" 53.13 "
"	V., "	I......	12.26 "		54.12 "	
"	V., "	I......	15.37 "	" 13.81 "	57.71 "	" 55.91 "

As in series X., there was an interval of several hours in the ammonia determination of the first and second culture in each set of parallels. It will be noted that in the gelatin cultures the chemical factor in ammonification is by no means as prominent as was the bacteriological factor studied in series X. Nevertheless, the addition of lime as affecting the chemical factor was not without influence. Thus, soil I., in the presence of the corresponding infusion, led to the production of less ammonia-nitrogen than did soil II., with the same infusion. The corresponding differences between soils II. and III., III. and IV., and IV. and V., are quite slight.

In the peptone solutions where the yields of ammonia-nitrogen were much greater than those in the gelatine solutions, the chemical differences in the soils, as brought about by the addition of lime, are likewise indicated. Thus, soil I. and corresponding infusion led to the production of 47.90 mg. of ammonia-nitrogen, whereas soil II., with the same infusion, led to the production of 51.91 mg. of ammonia-nitrogen. This was further increased to 53.05 mg., 53.13 mg. and 55.91 mg., as the amounts of lime admixed with the soil grew larger. It may safely be assumed, therefore, that the differences indicated are the results of the stimulating action of the chemical constitution of the soil on the development of the decay bacteria.

Ammonia-Nitrogen With the Same Soil and Different Infusions.

			Gelatin.		Peptone.	
oil V.,	Infusion	I	12.10 mg.		58.86 mg.	
" V.,	"	I......	15.86 "	Av. 13.98 mg.	57.88 "	Av. 58.37 mg.
" V.,	"	II	14.55 "		54 44 "	
" V.,	"	II......	18.31 "	" 16.43 "	59.84 "	" 57.14 "
' V.,	"	III	13.08 "		53.30 "	
" V.,	"	III......	17.00 "	" 15.04 "	60.33 "	" 56.81 "
' V.,	"	IV......	15.04 "		60.49 "	
" V.,	"	IV......	17.00 "	" 16.02 "	62 78 "	" 61.63 "
" V.,	"	V......	21 42 "		69.00 "	
" V.,	"	V	19.78 "	" 20.60 "	63.76 "	" 66.38 "

The data presented in the above table show differences preumably due to the character of the inoculating material. Comaring the amounts of ammonia found in the gelatin culture, we bserve that in the presence of soil V., infusion I. produced more mmonia-nitrogen than did any of the other infusions. Infuion II. gave higher returns than any of the others, with the xception of infusion V. Excluding infusion II., we find a gradally increasing yield of ammonia-nitrogen, as we pass from inusion I. to infusion V.

The results in the peptone solutions are more or less confuing. Infusion I. produced in the presence of soil V., 58.37 mg. f ammonia-nitrogen. This amount is probably somewhat reater than it should have been, since the average of cultures 9 and 30, duplicates of cultures 31 and 32, was only 55.91 mg. nfusion II. produced 57.14 mg. of ammonia-nitrogen, a larger uantity than was produced by infusion III., after that, hower, there was a gradually increasing production of ammonia om infusion III. to infusion V.

On the whole, both the chemical and bacteriological factors ave clearly affected the progress of ammonification as indicated y the above data. It is also indicated here that better results ill be secured where at least four parallel cultures are averaged 1 each case, and it is important to remember that the analytical ork on the cultures to be compared must be performed at the ame time. The other alternative is the treatment of the several altures, at any given time, with some substance that will stop arther ammonification.

Finally it should be pointed out here that the bacteriologica differences noted in series X. and in the present series are no quite the same. In the former case, the soils were mixed witl different quantities of calcium carbonate and allowed to stand The presence of the lime stimulated the development of certai organisms in the soil, hence at the end of several days th numbers as well as the physiological efficiency of the bacteria i the soil samples were different. When these soils, or their infu sions, were then used for inoculation, the numbers of bacteri introduced by them were not the same, and it is quite probabl that *qualitative* differences were also introduced thereby. As a result, the soil, or soil infusion, that introduced the greates number of bacteria, or a large number of the most vigorou organisms, into the culture medium showed the highest ammoni fication coefficient. Where sterile soil was used, however, an the culture solutions, containing different quantities of lime, wer inoculated with the same infusion, the numbers and vigor o the bacteria introduced were the same. Hence, in the progres of ammonification the chemical composition of the soil was th only variable. Nevertheless, because of the short duration o the experiment, the influence of the chemical factor did not fin as marked an expression as it did in the soils which had bee previously mixed with lime. Hence, in the inoculations of serie X., the differentiation began in the inoculating material itsel some time before it was used for inoculating purposes, wherea in series XI., in the comparison of the chemical factors, th differentiation began in the cultures themselves.

Series XII.

The culture solutions in this series contained egg-albumin insteac of peptone or gelatin. One gram of albumin was weighed off, in each case, into a 500 cc. flat-bottomed Jena flask, 100 cc. of tap water was poured over it, the flask stoppered with a cotton plug and sterilized in the autoclave at 1 3/4 atmosphere of pressure. The egg-albumin was thereby coagulated. The soils used for inoculation were designated as follows:

1. Very heavy clay soil, Matawan.
2. Sandy loam soil, Matawan.
3. Dark-colored clay loam soil, Princeton.
4. Reddish sandy loam soil, Clarksville.
5. Dark-colored sandy loam soil, Marlboro.
6. Reddish, fine-grained sandy loam soil, Freehold.
7. Asparagus soil I.
8. Asparagus soil II.
9. Asparagus soil III.

In each case there was added to the sterile water and albumin 10 grams of soil. Four inoculations were made from each soil, two of which were analysed at the end of six days, and two at the end of eight days.

Ammonia-Nitrogen in the Cultures.

	In 6 Days.		In 8 Days.	
Soil 1.........	52.76 mg.		71.74 mg.	
" 1.........	Lost	Av. 52.76 mg.	64.66 "	Av. 68.20 mg.
" 2.........	44.13 "		52.55 "	
" 2.........	46.33 "	" 45.23 "	62.98 "	" 57.76 "
" 3.........	36.02 "		63.15 "	
" 3.........	42.27 "	" 39.14 "	58.43 "	" 60.79 "
" 4.........	39.57 "		51.53 "	
" 4.........	38.89 "	" 39.23 "	51.53 "	" 51.53 "
" 5.........	49.55 "		70.05 "	
" 5.........	48.87 "	" 49.21 "	64.66 "	" 67.35 "
" 6.........	49.55 "		68.20 "	
" 6.........	44.13 "	" 46.84 "	70.05 "	" 69 12 "
" 7.........	45.49 "		61.80 "	
" 7.........	46.50 "	" 46.00 "	58.09 "	" 59 94 "
" 8.........	49.48 "		66.52 "	
" 8.........	52.42 "	" 50.95 "	Lost	" 66.52 "
" 9.........	46.84 "		57.92 "	
" 9.........	48.02 "	" 47.43 "	55.40 "	" 56.66 "

The amounts of ammonia-nitrogen found at the end of the six and the eight-day periods fail to show consistent relations. Thus, at the end of six days, the lowest yield of ammonia-nitrogen was secured in the case of soil 3, whereas the lowest yield of ammonia-nitrogen at the end of the eight-day period was secured in the case of soil 4. The highest yield of ammonia-nitrogen at the end of six days was secured in the case of soil 1, and at the end of the eight-day period in the case of soil 6. In the case of

three asparagus soils, the lowest ammonification coefficient was found in soil II., both in the gelatin and peptone solutions, whereas in the albumins of the present series soil II. showed the highest ammonification coefficient.

Series XIII.

The albumin of the preceding series was replaced here by finely-ground cottonseed meal. Two grams of the latter and 100 cc. of tap-water were used in each case. After sterilization in the customary manner, the cultures were each inoculated with 10 grams of soil. The soils used here were the same as those in series IX. and X., and contained, I.—no lime; II.—lime at the rate of .5 ton per acre; III.—lime at the rate of one ton per acre; IV.—lime at the rate of two tons per acre; V.—lime at the rate of three tons per acre. After standing at room temperature for six days, the several cultures were analysed for ammonia with the following results:

Ammonia-Nitrogen in the Cottonseed Cultures.

Soil	I	24.68 mg.	
"	I	25.36 "	Av. 25.02 mg.
"	II	21.47 "	
"	II	25.53 "	" 23.50 "
"	III	24.68 "	
"	III	18.80 "	" 21.74 "
"	IV	25.01 "	
"	IV	25.01 "	" 25.01 "
"	V	25.18 "	
"	V	30.41 "	" 27.79 "
No soil		2.12 "	

It will be seen that the results here are not decisive. The yield of ammonia-nitrogen in the case of soil I. was greater than that in the case of soil II., and still greater than that in the case of soil III. On the other hand, there was a progressive average increase from soil III. to soil V.

The results of this series, and likewise of series XII., would point to the conclusion that differences in the ammonifying power of soils may be brought out more readily in *solutions* of

nitrogenous substances than in solid nitrogenous substances. Peptone and gelatin solutions yield, for this reason, more uniform results than do albumin, casein and cottonseed meal. It may be that solution of albumin rendered non-coagulable by the addition of some iron sulphate as proposed by Marchal[1] would prove as satisfactory as the gelatin or peptone solutions, and would possess the further advantage of being more constant in composition. It should be added here that Lohnis[2] used bone meal as the material to be ammonified by the soil bacteria, and that his results with this substance were more or less in agreement secured under like conditions in peptone solutions. At any rate, the data presented in the above pages and elsewhere show clearly that further attention should be devoted to the study of methods.

Series XIV.

Ehrenberg found[3] that notwithstanding the far-reaching changes in the transformation of peptone nitrogen, due to inoculation of peptone solutions with soil, there was no actual decrease in the total nitrogen content of these solutions. "While it is rather surprising," he says,[4] "that notwithstanding the vigorous production of ammonia in the decaying solutions, there was apparently no appreciable loss of nitrogen, in the present experiment, through the volatilization of ammonia; the data reported here became of not inconsiderable significance, especially for the methods of bacteriological soil investigation." These observations of Ehrenberg's were supported by our own experiments.[5] To quote my own words: "It is interesting to note, in this connection, that the far-reaching transformation of peptone nitrogen, as noted in the above experiments, did not, on the whole, involve any losses of nitrogen." The duration of Ehrenberg's experiment was twelve days, of ours eight days. It was of interest to determine, therefore, whether losses of nitrogen

[1] Annales de la Societe Belge de Microscopie, vol. XVII. (1893), p. 77.
[2] Centr. f. Bakt, etc., part II., vol. XIV., p 1.
[3] Centr. f. Bakt., etc., part II., vol. XV., p. 154.
[4] l. c., p. 157.
[5] N. J. Stat. Rep., 1905, p. 238.

would occur in a similar experiment of considerably greater duration. Accordingly, a culture solution was made up as follows:

10 gms. Witte's peptone.
0.1 " K_2HPO_4.
0.1 " $MgSO_4$.
1,000 cc. tap-water.

100 cc. portions of this solution were distributed in 500 cc. round, flat-bottomed Jena flasks, sterilized in the autoclave, cooled and inoculated with 20 cc. of soil infusion prepared by shaking for five minutes, 300 grams of soil in 600 cc. of sterile tap-water. It was already demonstrated in the above pages that practically all of the bacteria in the soil can be thus brought into suspension, hence a bacterial equivalent of 10 grams of soil was used for inoculation in each case.

The inoculating material consisted of three soils of the same origin, but differentiated by fertilizer treatment. Determinations were made of ammonia, of soluble and insoluble nitrogen, and of total nitrogen at the end of three days, seven days and thirty-two days, respectively. Ammonia was determined by adding to each culture about 100 cc. of water and an excess of magnesia, and distilling over into standard hydrochloric acid. Soluble and insoluble nitrogen were separated by the addition to the culture of a strong solution of basic lead acetate, and subsequent filtration and washing. The precipitate thus secured represented the originally soluble peptone nitrogen transformed into the more complex nitrogenous compounds of the bacterial cells, while the filtrate represented the peptone nitrogen still unchanged, or changed into more simple compounds like the amino-acids and their derivatives, or the ammonium compounds. As will be shown presently, by far the largest proportion of the soluble nitrogen consisted of ammonia-nitrogen, already at the end of three days, while at the end of seven days practically all of the soluble nitrogen consisted of ammonia-nitrogen. The nitrogen determination was made in each case according to the Kjeldahl method. The following amounts of ammonia-nitrogen were found:

Nitrogen as Ammonia.

	In 3 Days.		In 7 Days.		In 32 Days.	
Soil I......	91.82 mg.		117.35 mg.		89.25 mg.	
" I......	89.28 "	Av. 90.55 mg.	117.19 "	Av. 117.27 mg.	83.33 "	Av. 86.29 mg.
" II......	85.90 "		112.11 "		79.82 "	
" II......	83.70 "	" 84.80 "	115.32 "	" 113.71 "	83.86 "	" 81.84 "
" III......	68.15 "		115.32 "		85.55 "	
" III......	72.88 "	" 70.51 "	109.24 "	" 112.28 "	73.25 "	" 79.40 "

The ammonifying power of the infusion from soil I. proved greater than that from soil II., and the latter superior to that from soil III. The differences were most marked at the end of three days, but still persisted at the end of more than a month. At the end of seven days greater amounts of ammonia-nitrogen were found in the cultures than were found at the end of three days; yet, strange as it may seem, the amounts of ammonia-nitrogen found at the end of thirty-two days were scarcely greater than the corresponding amounts at the end of three days; in soils I. and II. they were actually smaller. This striking diminution in the quantity of ammonia-nitrogen in the cultures may be attributed either to the formation of insoluble nitrogen compounds at the expense of the ammonia-nitrogen, or the liberation of nitrogen from the cultures as ammonia, or free nitrogen. The probable source of loss will be discussed more fully in connection with the other analytical data.

Total Soluble Nitrogen.

	In 3 Days.		In 7 Days.		In 32 Days.	
Soil I......	118.54 mg.		124.29 mg.		90.94 mg.	
" I......	117.19 "	Av. 117.83 mg.	120.23 "	Av. 122.26 mg.	90.77 "	Av. 90.85 mg.
" II......	116.68 "		123.44 "		87.57 "	
" II......	115.16 "	" 115.90 "	125.64 "	" 124.54 "	88.24 "	" 87.90 "
" III......	114.65 "		119.55 "		85.21 "	
" III......	123.10 "	" 118.87 "	119.39 "	" 119.47 "	93.63 "	" 89.42 "

Total Insoluble Nitrogen.

	In 3 Days.		In 7 Days.		In 32 Days.	
Soil I......	28.24 mg.		22.49 mg.		20.54 mg.	
" I......	26.72 "	Av. 27.48 mg.	20.97 "	Av. 21.73 mg.	21.05 "	Av. 20.79 mg.
" II......	28.41 "		19.10 "		20.71 "	
" II......	25.36 "	" 26.88 "	19.61 "	" 19.35 "	21.56 "	" 21.13 "
" III......	29.08 "		18.60 "		23.57 "	
" III......	26.89 "	" 27.98 "	18.60 "	" 18.60 "	22.56 "	" 23.06 "

Total Soluble and Insoluble Nitrogen.

	In 3 Days.		In 7 Days.		In 32 Days.	
Soil I......	146.78 mg.		146.78 mg.		111.48 mg.	
" I......	143.91 "	Av. 145.34 mg.	141.20 "	Av. 143.99 mg.	111.82 "	Av. 111.65 mg.
" II......	145.09 "		142.54 "		108.28 "	
" II......	140.52 "	" 142.80 "	145.25 "	" 143.89 "	109.80 "	" 109.04 "
" III......	143.73 "		138.15 "		108.78 "	
" III......	149.99 "	" 146.86 "	137.99 "	" 138.07 "	116.19 "	" 112.48 "

The analytical data presented in the above tables show, in the first place, that the quantity of soluble nitrogen had increased perceptibly from the third to the seventh day. It must be assumed, therefore, that a portion of the peptone nitrogen, which had been rendered insoluble in the course of the first three days, was again made soluble by the increased activity of the bacteria. On the other hand, there was a very marked decrease in the amount of soluble nitrogen at the end of thirty-two days. Taking the average amounts found at the end of seven and of thirty-two days, we find the following apparent losses of soluble nitrogen:

Soil I........	31.41 mg.	Average, 23.70 mg.
" II........	36.64 "	
" III........	30.05 "	

Similarly, taking the differences between the average amounts of ammonia found at the end of seven and of thirty-two days, respectively, we obtain the following figures:

Soil I........	30.98 mg.	Average, 31.91 mg.
" II........	31.87 "	
" III........	32.88 "	

It would seem, therefore, that the loss of nitrogen from the cultures fell entirely to the share of the ammonia. While it is uncertain whether all of the ammonia was lost as such, or whether some gaseous nitrogen was also set free in the course of decay, there is good reason for assuming that under the conditions of the experiment by far the greatest part of the loss occurred as ammonia. The simplification of the peptone involving as it did the formation of amino-acids and ammonia, and like-

wise of large quantities of carbon dioxide, led to the formation of ammonium carbonate. The accumulation of the latter in the culture solutions, and its gradual volatilization, necessarily led to the decrease of combined nitrogen. There is no certainty, at the same time, that some of the combined nitrogen was not set free through the oxidation of the ammonia. A comparison of the amounts of soluble nitrogen present at the end of each period with the corresponding amounts of ammonia-nitrogen will show the following :

Soluble Nitrogen Less Ammonia-Nitrogen.

	In 3 Days.	In 7 Days.	In 32 Days.
Soil I........................	27.28 mg.	4 99 mg.	3.56 mg.
" II........................	31.10 "	10 83 "	6.16 "
" III........................	48 36 "	7.19 "	10.02 "

At the end of three days there was still a considerable amount of soluble nitrogen present in the cultures, which was not ammonia-nitrogen. In other words, a portion of the peptone originally present in the solution was still intact. At the end of seven days the proportion of the soluble non-ammonia-nitrogen had diminished considerably. Only a comparatively slight amount of the soluble nitrogen was in the form of soluble protein, peptone, albumose, or amino-acid nitrogen.

Comparing the amounts of insoluble nitrogen found at the end of each period, we note that the greatest proportion of insoluble nitrogen was present in the cultures at the end of three days. After this there was a slight decrease in the few days following, and but little change after that. It would seem, on the whole, that the bacterial activities subsequent to the seventh day did not affect the quantity of insoluble protein nitrogen in the cultures.

The Amounts of Total Nitrogen Present in the Cultures.

	In 3 Days.		In 7 Days.		In 32 Days.	
Soil I......	144.58 mg.		145.59 mg.		108.62 mg.	
" I......	141.54 "	Av. 143.06 mg.	147.29 "	Av. 146.44 mg.	106.93 "	Av. 107.77 mg.
" II......	145.43 "		147.45 "		108.11 "	
" II......	153.20 "	" 149.31 "	147.79 "	" 147.62 "	112.49 "	" 110.30 "
" III......	140.01 "		142.55 "		123.10 "	
" III......	143.23 "	" 141.62 "	142.71 "	" 142.63 "	123.27 "	" 123.18 "

The direct determinations of total nitrogen show likewise a very pronounced loss of combined nitrogen, that must have occurred in the interval between the second and third periods. Comparing these with the sum of the soluble and insoluble nitrogen quantities, we find a fairly good agreement, notwithstanding some differences due to analytical and other errors. The losses of combined nitrogen between the second and third periods point in the same direction, whether calculated from the one or the other set of cultures, as the following figures will show:

Losses of Combined Nitrogen Calculated from—

	Soluble and Insoluble Nitrogen.		Total Nitrogen.	
Soil I.	32.34 mg.	Av. 30.93 mg.	38.67 mg.	Av. 31.81 mg
" II.	34.85 "		37.32 "	
" III.	25.59 "		19.45 "	

The losses in the total nitrogen determinations are greater in the case of soils I. and II. than they are in the corresponding soils when calculated from the sum of the soluble and insoluble nitrogen. The reverse is true of soil III. In the latter case the losses were unmistakably smaller than the corresponding losses in the other soil inoculations. Thus in the total nitrogen determinations, the loss of combined nitrogen between the second and third periods in the case of soil III. was only 19.45 mg., whereas in the case of soil I. it was 38.67 mg., or almost double in quantity. These differences are due partly to the smaller amounts of nitrogen found in the case of soil III. at the end of the seven-day period, and partly to the larger amounts found at the end of the thirty-two-day period. Thus the sum of the soluble and insoluble nitrogen at the end of the seven-day period was 138.07 mg. in the case of soil III., and 143.99 mg. and 143.89 mg. in the case of soils I. and II., respectively. At the end of the thirty-two-day period the corresponding figures were 112.48 mg., 111.65 mg. and 109.04 mg., respectively. Similarly in the total nitrogen determinations there were found at the end of the seven-day period 142.63 mg. for soil III., and 146.44 mg. and 147.62 mg. for soils I. and II., respectively. At the end of the thirty-two-day period the corresponding figures were 123.18 mg., 107.77 mg. and 110.30 mg., respectively.

Bacteriological Indications of the Mineral Requirements of Soils.

The ammonification studies reported in the above pages, and similar studies in nitrification and denitrification, deal primarily with the transformations of a single of the plant-food constituents—nitrogen. At the same time, the vigor of the nitrification processes, and more especially of the ammonification processes, may under certain conditions be made a measure of the general fertility relations in the soil. On theoretical grounds, this will seem quite plausible, from the fact that bacteria are microscopic plants, and that the conditions of temperature, moisture, and of the supply of mineral salts most favorable for the development of the soil bacteria, are also favorable for the growth of higher plants. It would seem, further, theoretically, that nitrogen-fixing bacteria of the Azotobacter type, which are largely independent of the supply of combined nitrogen in the soil, could be made to grow in mannite or dextrose solutions devoid of any mineral nutrients, but provided with quantities of sterile soil. Theoretically, it would also appear that the development of the Azotobacter organisms, and the accompanying fixation of nitrogen, should be in proportion to the amount of mineral nutrients supplied by the sterile soil; hence equal quantities of soil of unequal mineral fertility, or varying quantities of soil of the same mineral fertility, should yield, with the aid of the Azotobacter organisms, different quantities of combined nitrogen. The decay bacteria on the one hand, and the nitrogen-fixing bacteria on the other, furnish an analogy here to the nitrogen-consuming and nitrogen-gathering higher plants. The members of the first group are frequently limited in their growth by the small supply of combined nitrogen, which serves then as the controlling factor, while the members of the second group are, under the same conditions, limited in their growth by the supply of phosphorus, of potassium, or of lime. It seems reasonable to assume, thus, that by varying the quantities of soil added to the solutions of mannite some standard of comparison could be established. By adding, likewise, varying amounts of the salts of phosphorus, or of potassium, to mannite solutions containing a definite amount

of soil, a comparative measure could be secured of the phosphorus or potassium requirements of any given soil, similarly to the method pursued in vegetation experiments for the establishment of the fertilizer requirements of soils. A bacteriological method of this character would be a very valuable addition to our resources in the study of soil fertility problems, for it would enable us to ascertain in two or three weeks, and in some instances in but a few days, facts which in vegetation experiments require for their establishment at least one season of growth. The preliminary experiments reported in the following pages were arranged to test the correctness of the theoretical considerations outlined above.

Series XIV.

This series consisted of a comparison of eight soils as a source of mineral plant-food to *Azotobacter vinelandii* growing in mannite solutions. The eight soils employed here were of the following origin:

Soil 1. Clay loam, College Farm.
" 2. Original cylinder soil.[1]
" 3. Original box soil.[2]
" 4. Sandy soil, Vineland.
" 5. Clay soil, Woodstown.
" 6. Clay loam, cylinder soil I[3]
" 7. " " " " II.[3]
" 8. " " " " III.[3]

The soils were all ground to pass a .5 mm. sieve, and had been kept in this condition in glass-stoppered bottles for three years or more. Varying quantities of each of these soils were employed and designated as follows: *a*, 50 mg.; *b*, 100 mg.; *c*, 300 mg.; *d*, 1,000 mg.; *e*, 2,000 mg., and *f*, 5,000 mg. of soil.

After the corresponding amounts of soil were weighed off, there was added to each culture flask 100 cc. of distilled water, containing 1.5 gms. of mannite. The flasks were stoppered with cotton plugs, sterilized in the customary manner, and inoculated when cool with a pure culture of *A. vinelandii*. The following amounts of nitrogen were found in the different cultures at the end of twenty-five days:

[1] N. J. Stat. Rep. 1899, p. 97.
[2] N. J. Expt. Stations, Bull. 180.
[3] N. J. Stat. Rep. 1899, p. 97.

Scheme of Inoculation.

	Amount of Soil Used.	Nitrogen Found.	Nitrogen in Soil.	Nitrogen Fixed.
1a	50 mg.	......	......	......
1b	100 "	......	......	......
1c	300 "	......	......	......
1d	1000 "	......	......	......
1e	2000 "	3.40 mg.	2.58 mg.	.82 mg.
1f	5000 "	*13.44 "	6.45 "	6.99 "
2a	50 "	......	......	......
2b	100 "	......	......	......
2c	300 "	1.70 "	.58 "	1.12 "
2d	1000 "	5.10 "	1.95 "	3.15 "
2e	2000 "	3.91 "	3.90 "	......
2f	5000 "	10.20 "	9.75 "	.45 "
3a	50 "	......	......	......
3b	100 "	......	......	......
3c	300 "	......	......	......
3d	1000 "	......	......	......
3e	2000 "	......	......	......
3f	5000 "	*8.68 "	3.95 "	4.73 "
4a	50 "	......	......	......
4b	100 "	......	......	......
4c	300 "	......	......	......
4d	1000 "	......	......	......
4e	2000 "	......	......	......
4f	5000 "	1.87 "	1.90 "	......
5a	50 "	......	......	......
5b	100 "	......	......	......
5c	300 "	......	......	......
5d	1000 "	......	......	......
5e	2000 "	......	......	......
5f	5000 "	6.81 "	7.45 "	......
6a	50 "	......	......	......
6b	100 "	......	......	......
6c	300 "	......	......	......
6d	1000 "	1.87 "	1.51 "	.36 "
6e	2000 "	5.28 "	3.02 "	2.26 "
6f	5000 "	11.90 "	7.55 "	4.35 "
7a	50 "	......	......	......
7b	100 "	......	......	......
7c	300 "	......	......	......
7d	1000 "	......	......	......
7e	2000 "	4.76 "	2.88 "	1.88 "
7f	5000 "	13.27 "	7.20 "	6.07 "
8a	50 "	......	......	......
8b	100 "	......	......	......
8c	300 "	......	......	......
8d	1000 "	4.76 "	1.65 "	3.11 "
8e	2000 "	*5.79 "	3.30 "	2.49 "
8f	5000 "	12.42 "	8.25 "	4.17 "

Macroscopical examination failed to reveal any growth in 1a-1d, 2a-2b, 3a-3e, 4a-4f, 5a-5f, 6a-6c, 7a-7d and 8a-8c, and these cultures were not analysed with the exception of 4f and 5f. Cultures 1f, 3f and 8e, marked with an asterisk (*), probably gave low results on account of the severe bumping of the flask and contents during digestion.

It will be observed that quantities of soil less than one gram did not furnish enough mineral nutrients to the Azotobacter organisms to allow a more or less normal growth. Only one exception is to be recorded here, namely, in the case of 2c; still even here the amount of development, as measured by the amount of nitrogen fixed, was rather slight. In the case of two soils, 4 and 5, there was no perceptible development of the Azotobacter organisms even in the presence of five grams of soil. In the case of the first of these, soil 4, this result is not at all surprising, since it is a very poor soil, almost a pure quartz sand. In the case of soil 5, this result is not quite as intelligible, since it is a heavy clay soil, rich in nitrogen, and presumably also rich in the mineral nutrients. Soils 1, 2, 3, 6, 7 and 8 showed macroscopically and microscopically an abundant growth of Azotobacter in some of the cultures, and on chemical examination of the latter th were revealed decided gains of nitrogen. The gains of nitrog increased with the increasing quantity of soil present in the c ture in the case of soils 1, 3, 6, 7 and 8. On the other hand, t increasing amounts of soil from 2c to 2f were not accompani by increased yields of combined nitrogen.

It may also be noted here that some of the soils must ha furnished very considerable quantities of available mineral r trients, since the fixation of nitrogen was in some instances ve marked, as in the case of 1f and 7f, where the amounts of nit gen fixed exceeded 4 mg. per gram of mannite used up. (the whole, therefore, there were decided differences brought (in this experiment between soils of different origin, while in so of the same origin, but differently fertilized, as in the case soils 6, 7 and 8, the differences were not as decisive.

Series XV.

In order to determine, further, the effect of larger quantities of the same soils on the growth of *Azotobacter vinelandii*, a similar series of inoculations was made with a, 5 gms.; b, 10 gms., and c, 15 gms., respectively, of each soil. As in series XIV., the mannite, at the rate of 15 gms. per liter, was dissolved in distilled water, and 100 cc. of this solution was used in each case. The cultures were kept at room temperature from June 29th until August 21st.

Scheme of Inoculation.

	Amount of Soil Used.	Nitrogen Found.	Nitrogen in Soil.	Nitrogen Fixed.
1a	5 gms.	14.82 mg.	6.45 mg.	8.37 mg.
1b	10 "	*16.30 "	12.90 "	3.40 "
1c	15 "	*24.41 "	19.35 "	5.06 "
2a	5 "	13.81 "	9.75 "	4.06 "
2b	10 "	*22.56 "	19.50 "	3.06 "
2c	15 "	Lost	......	.....
3a	5 "	11.78 "	3.95 "	7.83 "
3b	10 "	*15.15 "	7.90 "	7.25 "
3c	15 "	*17.85 "	11.85 "	6.00 "
4a	5 "	2.02 "	1.90 "	0.12 "
4b	10 "	3.87 "	3.80 "	0.07 "
4c	15 "	6.40 "	5.70 "	0.70 "
5a	5 "	7.24 "	7.45 "	.....
5b	10 "	14.41 "	14.90 "	.....
5c	15 "	24.40 "	22.35 "	2.05 "
6a	5 "	12.96 "	7.55 "	5.41 "
6b	10 "	18.02 "	15.10 "	2.92 "
6c	15 "	Lost	......	.....
7a	5 "	12.96 "	7.20 "	5.76 "
7b	10 "	24.58 "	14.40 "	10.18 "
7c	15 "	29.30 "	21.60 "	7.70 "
8a	5 "	13.98 "	8.25 "	5.73 "
8b	10 "	22.73 "	16.50 "	6.23 "
8c	15 "	39.07 "	20.21 "	18.86 "

It should be noted in the comparison of the above results, tha 1b, 1c, 3b and 3c bumped strongly during digestion, and ma have lost slight amounts of nitrogen ; 2c and 6c were eliminate entirely, because of the too violent bumping on the digestion fur nace. *In general, it may be stated here that the safe digestio* of five or more grams of soil offers considerable difficulty wher the material is not ground sufficiently fine, and while in the de terminations marked with an asterisk (*) the actual losses wer perhaps scarcely appreciable, it was deemed safe to make a not of it, and so provide for possible errors in the interpretation o the results.

The data presented above are of no little interest in showin how different soils may give up mineral salts to mannite solu tions, with which they are in contact, in quantities large enoug to supply the needs of vigorously-growing Azotobacter cells. Ma croscopical examination, immediately before digestion, showe Azotobacter growths in all of the cultures except those inoculate *with soils 4 and 5. Microscopical examination showed the pres* ence of numerous Azotobacter cells in all of the cultures excep those inoculated with soils 4 and 5. The organisms showed very pronounced motility, and were apparently uncontaminate with other bacteria ; an exception to this was noted in 2a, where few small bacilli were also observed. In the inoculations wit soils 4 and 5, there were few, if any, Azotobacter cells present i 4a, 4b, 5a and 5b, and few in 4c and 5c.

The experiments of Gerlach and Vogel[1] demonstrated that i the absence of phosphates or of lime in the culture solutions there was practically no Azotobacter growth, and a diminishe growth without salts of potassium or sodium. They found th following gains of nitrogen as compared with similar uninocu lated solutions :

	In 45 Days.	In 67 Days.
Complete mineral food	26.0 mg.	42.5 mg.
Without calcium	1.9 "	0.4 "
" potassium	21.4 "	18.9 "
" phosphorus	1.0 "	0.1 "
" potassium and phosphorus	......	0.2 "
" sodium	14.4 "	15.3 "
" potassium and sodium	18.1 "	19.5 "

[1] Centr. f. Bakt., etc., part II., vol. X. (1903), p. 636.

It was likewise demonstrated by the writer[1] that the fixation of itrogen by *A. vinelandii* is very slight where compounds of iron re not present in the culture medium. Similar observations ere made by Heinze, who noted[2] that "all cultures without hosphates showed no Azotobacter growth."

The foregoing facts made it quite evident that the bacteria ere enabled to grow more or less vigorously, because of the presnce in the mannite solutions of mineral nutrients derived from e soil. It is evident, also, that everything being equal, bacteal growth will be determined by the rate of solution of the ineral nutrients, and particularly of the soil phosphates. As ated by Schreiner and Failyer[3]: "The removal of the absorbed hosphate appears to be in general the same as the removal of e phosphate from the original soil. The concentration of the ercolates becomes constant when only a fractional part of the bsorbed phosphate has been removed, and this concentration is ractically that yielded by the original soil with a far less phoshate content. It would, therefore, seem that the concentration f *the phosphate in the soil solution is practically the same*, hether the soil contains a large or a small quantity of absorbed hosphate, and that it is this absorptive power of the soil which ontrols the concentration of the phosphate in the free soil oisture. It follows that with change in the absorptive power f the soil the concentration of the phosphate in the free soil oisture would also change." "It is thus made manifest," says ameron, in the preface to this bulletin, "that the absorptive ower of the soil is to a much larger extent than any other the ontrolling factor in regulating the concentration of the soil soluon, and that, in the absence of some exceptional disturbing ause, the concentration will remain practically constant. It urther appears that different soils will yield solutions of the ame order of concentration."

These conclusions are not accepted by Hall and Amos.[4] "But ven assuming," they say, "that the soil gives rise to a solution

---

[1] N. J. Stat. Rep., 1903, p. 276.
[2] Centr. f. Bakt., etc., part II., vol. XIV. (1905), p. 174.
[3] Bull. 32, Bureau of Soils, Washington, D. C., p. 39.
[4] Transactions Chemical Society (London), 1906, vol. 89, p. 205.

of constant concentration, the mass of the constituent in the soil would still come into play by regulating the ease or the frequency with which the solution could be renewed. If, for example, the phosphates in the soil give rise to a solution of phosphoric acid in the soil water, the strength of which is independent of the mass of phosphate present, yet as soon as the crop withdraws phosphoric acid from the solution, the equilibrium will be disturbed and more phosphate will be attacked. But the rapidity with which the phosphate will pass into solution, and in its turn to the plant, will be conditioned by the mass of it present, and if the amount is near the limit required for saturation of the soil water, then the solution might not be replenished as often as the plant requires. Thus, even if a particular substance establishes a solution of constant composition in the soil water, its mass will still affect the supply of nutrient to the plant, because with it is bound up the renewal of the solution as it becomes depleted by the growth of the plant.

"Again, a soil solution of constant composition would necessitate the identity in all soils of the state of combination of the constituent in question. If, for example, all soils contained a similar tricalcium phosphate, and no other compound of phosphoric acid, then the soil water in equilibrium with the soil would attain the same concentration of phosphoric acid, whatever the amount of phosphate in the soil. This identity, however, of the compounds of phosphoric acid in all soils has not been demonstrated."

After reporting a series of experiments where carbonated water or 1 per cent. citric acid solutions were employed as solvent of the soil phosphates, these authors add[1] that: "After reviewing the experiments as a whole, it may be concluded that the soil contains compounds of phosphoric acid of varying solubility; the more easily dissolved compounds removed in the first few extractions are present in comparatively small amounts, so that the amounts going into solution fall rapidly with each extraction. After the fourth or fifth extraction, a point is reached when the compound remaining in the soil seems to be uniform

[1] l. c., p. 218.

as shown by the approximately constant concentration in phosphoric acid, which the later solutions now attain. This constant equilibrium point is not, however, the same for all soils; it is evidently determined by certain differences in the nature of the phosphoric acid compounds, which are characteristic of each soil.

"The results lend no support to Whitney's theory, that all soils will form in nature solutions of approximately constant composition, representing an equilibrium between the soil phosphoric acid and the solvent water which is independent of the mass of the former, for although the 1 per cent. solution is a *much more drastic solvent than the natural soil water, there* is no reason to suppose that its action will be essentially different in kind; indeed, one of us has already attempted to show that all weak acid solvents attack the soil in a very similar fashion. The present results indicate that there are essentially different compounds of phosphoric acid in different soils, possessing initially different points of equilibrium with solvents, and the more soluble of these compounds are present in such comparatively small amounts that their mass becomes a factor in the maintenance of the strength of the solution. In other words, the soil water will be of varying concentration in phosphoric acid in different soils, and when the crops remove this phosphoric acid by their growth, the soils will again differ in their power of renewing the solution, because of variations in the mass as well as the nature of the phosphate which gave rise to the original solution."

The above statements, purposely cited at length, are significant in affording data for the interpretation of the experimental results reported here. The growth of the Azotobacter organisms in the mannite solutions, the formation of carbon dioxide in accompanying this growth, and the presence of the mannite itself, each exerted a certain effect on the solution of the soil phosphates. The soils which yielded the greatest amount of phosphates to the mannite solution allowed also the most vigorous development of the bacteria. On the other hand, the solutions which contained the organisms growing most vigorously parted most rapidly with their phosphates, and thereby hastened the

further solution of the soil phosphates. For this reason there was proportionately and absolutely more Azotobacter growth in the mannite solutions containing larger amounts of phosphates of greater initial solubility.

Turning now to the analytical data presented above, we find that in the case of soil 1 the largest yield of combined nitrogen was secured in the presence of five grams of soil. The same was true, also, of soils 2 and 3. In the case of soil 4, there was no growth in the presence of fifteen grams of soil. In the case of soil 5, there was no growth in the presence of five grams or ten grams of soil, and slight growth in the presence of fifteen grams of soil. These results are instructive in showing that two of the soils, 4 and 5, one a very light sandy soil (Windsor Sand), and the other a stiff clay soil (Alloway Clay), failed to yield enough mineral nutrients, and particularly of calcium phosphate, to permit of a more or less extensive growth of Azotobacter. A slight growth occurred only when as much as fifteen grams of soil had been added to the mannite solution. The results are no less interesting in the case of soils 6, 7 and 8, all of the same origin, but differentiated by fertilizer treatment, in the five-year period, 1898–1903. Originally identical with soil 2, they were treated as follows:

Soil 6 was cropped during this period without the addition of manures or fertilizers.

Soil 7 was similarly cropped, with annual additions of acid phosphate and of muriate of potash, at the rate of 640 pounds and 320 pounds, respectively, per acre.

Soil 8 was similarly cropped, with the same applications of acid phosphate and of muriate of potash, and, in addition thereto, fresh cow manure at the rate of about sixteen tons per acre, annually.

Comparing, therefore, soils 2, 6, 7 and 8, we find that the two first named, when used in five-gram quantities, yielded more combined nitrogen than they did when used in ten-gram quantities. Furthermore, soils 7 and 8, which had received applications of phosphate, gave not only higher yields of combined nitrogen in the presence of ten grams of soil, as compared with

the corresponding five-gram quantities, but also gave higher yields than any of the other soils. In the case of soil 8, the yield of combined nitrogen, in the presence of fifteen grams of soil, was 18.86 mg., or at the rate of more than 12.5 mg. per gram of mannite consumed. For the rest, these experiments must be regarded as preliminary merely. It is believed that by using one cubic centimeter of culture for inoculation, instead of one loopful, the very essential initial differences will be eliminated, and the results secured will be more constant and uniform. It is also proposed to use other Azotobacter species in these studies, and to compare a larger number of soils, whose previous history is known.

In conclusion, I would express my appreciation to Lester H. Williamson, for his faithful assistance in the prosecution of this work.

REPORT OF THE HORTICULTURIST.

REPORT OF THE HORTICULTURIST.

G. F. WARREN, PH.D., HORTICULTURIST.

JENNIE A. VOORHEES, A.B., ASSISTANT.

Three chief lines of work have been conducted during the past year; farmers' institutes, experimental work, publications.

Farmers' institute work.—Nearly three months was spent in institute work, and in attendance at meetings of County Boards of Agriculture. At these meetings, special emphasis has been given to three subjects: spraying of fruits and truck crops, the renewal of the peach industry, and agricultural education. Plant-breeding, tillage and fertilization of orchards, and other questions were occasionally presented.

Publications.—During the year two bulletins and this report have been prepared.

Bulletin 194, Spraying; 60 pages.

Bulletin 197, Suggestions on the Renewal of the Peach Industry in New Jersey, 46 pages.

Experimental work.—The fertilizer, irrigation and variety tests that were started eleven years ago were continued. Various spraying experiments were conducted. Work in breeding rust resistant, good strains of asparagus has been started. An experimental peach orchard of 1,032 trees was planted at High Bridge. Several co-operative experiments were conducted in the State. Experiments in the forcing of vegetables in the greenhouses were performed. The results of this work are given in this report, except the experiments on peaches which were reported in Bulletin No. 197.

The fertilizer and irrigation trials, and weather records were started by Mr. A. T. Jordan, eleven years ago. The later records have been kept by Miss J. A. Voorhees and Mr. George D. Manning.

PLANT-FOOD REMOVED BY A PEACH TREE IN TEN YEARS' GROWTH.

Records have been kept at this Station for ten years, in order to determine the amount of plant-food used by apples, pears, cherries, plums, peaches, quinces and asparagus. The orchards were set in 1896. Two trees each of plum and pear and one tree of each of the other kinds have been included in the test. The leaves, prunings and fruit have been collected, weighed and analysed each year.

Details of work with peach tree.—The peach tree was a one-year-old Crawford's Late, set in 1896 in part of the orchard that has been regularly tilled, but that has received no fertilizer since the first year. The soil is a gravelly loam of medium fertility, mapped by the Bureau of Soils as "Penn Stony Loam." No account is made of the plant-food in the tree when it was planted, as it was too small to affect the results. The tree made a fairly good growth as can be seen by Fig. 1. It did not, however, yield very large crops, only about five baskets of fruit (128 pounds) in the ten years. The average yield per tree in this orchard has been 277 pounds.

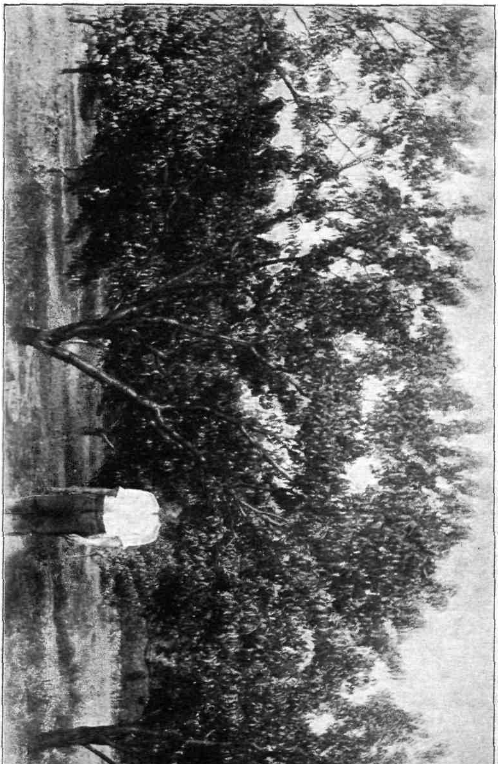
The leaves and prunings were saved as mentioned above. In the fall of 1905, the writer had the tree carefully dug out so as to get all the fine roots so far as possible. The tree was divided into five parts for weight and analysis as follows:

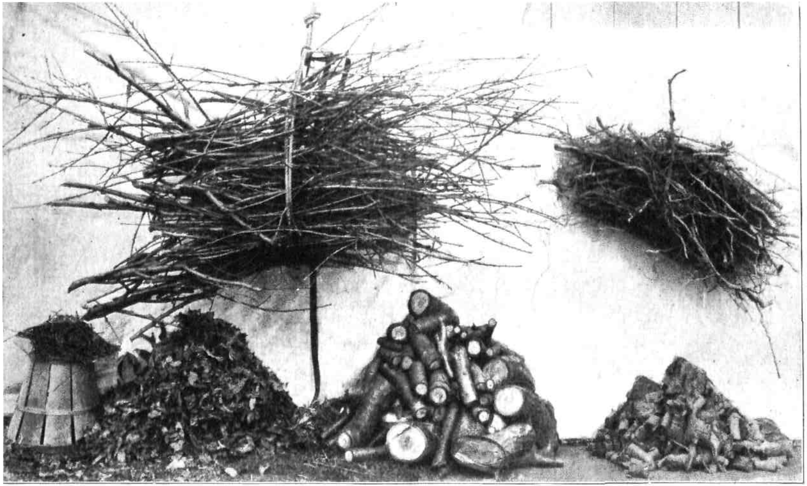
1. The 1905-growth, cut from the tips of all twigs.
2. The remaining twigs up to one inch in diameter.
3. Remainder of the top to the surface of the ground.
4. Roots larger than one inch in diameter.
5. Roots smaller than one inch in diameter.

To obtain a sample of the trunk, it was sawn into pieces about eight inches in length, and a 300-gram sample of the sawdust was taken.

The larger roots were washed and sampled in the same way. The smaller roots and twigs were sampled by cutting a number of each into small pieces with pruning shears. See Fig. 2.

All chemical analyses were made under the direction of J. P. Street. In computing the amounts removed the analyses were





Twigs grown in 1905. | Leaves. | Wood up to one inch in diameter. | Larger wood. | Small roots. | Large roots.

Fig. 2.

The tree divided into different parts for weight and analysis.

irried to three decimal places, but only two are given in the ible. The records of leaves, fruit and twigs previous to 1905 ere kept by A. T. Jordan and Miss Jennie A. Voorhees.

TABLE 1.

omposition of Leaves and Total Plant-Food Removed by Them.

YEAR.	Total weight.	CHEMICAL ANALYSIS.							AMOUNT REMOVED.			
		Water.	Organic matter.	Ash.	Nitrogen (N).	Phosphoric acid (P_2O_5).	Potash (K_2O).	Lime (CaO).	Nitrogen (N).	Phosphoric acid (P_2O_5).	Potash (K_2O).	Lime (CaO).
	grams.	%	%	%	%	%	%	%	grams.	grams.	grams.	gms.
96..................	570	65.80	31.08	3.12	1.37	0.23	0.48	......	7.8	1.3	2.7	....
97..................	2,290	65.49	30.44	4.07	1.22	0.23	0.75	......	27.9	5.3	17.2	....
98..................	5,460	64.69	31.47	3.84	1.27	0.19	0.74	......	69.3	10.4	40.4	....
99..................	8,550	58.16	36.84	5.00	1.40	0.26	0.79	......	119.7	22.2	67.6	....
00..................	8,800	57.96	37.99	4.05	1.12	0.21	0.50	......	98.4	18.0	44.1	....
01..................	16,130	65.37	31.05	3.58	0.86	0.17	0.48	......	138.3	27.4	77.4	....
02..................	12,480	66.69	29.87	3.44	0.70	0.14	0.32	......	87.6	17.2	40.3	....
03..................	11,500	62.70	32.95	4.35	0.75	0.18	0.45	......	86.3	21.2	51.5	....
04..................	7,050	52.05	42.39	5.56	1.31	0.28	0.88	......	92.6	19.9	62.0	....
05..................	4,520	33.37	57.09	9.54	1.71	0.36	1.03	1.32	77.4	16.3	46.6	59.7
Average........	....	59.24	36.12	4.66	1.17	0.23	0.64	......	....	....	....	....
Total	77,350	....	....	......	......	......	......	......	805.3	159.2	449.8	....
Total pounds.	170.5	....	....	......	......	......	......	......	1.775	0.351	0.901	....

TABLE 2.

Composition of Prunings and Total Plant-Food Removed by Them.

YEAR.	Total weight.	CHEMICAL ANALYSIS. Water.	Organic matter.	Ash.	Nitrogen (N).	Phosphoric acid (P_2O_5).	Potash (K_2O).	AMOUNT REMOVED. Nitrogen (N).	Phosphoric acid (P_2O_5).	Potash (K_2O).
	grams.	%	%	%	%	%	%	grams.	grams.	grams.
1896	150	52.57	45.15	2.28	0.65	0.13	0.29	1.0	0.2	0.4
1897	[1]930	70.28	27.27	2.45	0.91	0.20	0.53	8.5	1.9	5.0
1897	690	52.02	46.29	1.69	0.44	0.14	0.21	3.0	1.0	1.5
1898	1,100	43.61	54.57	1.82	0.47	0.14	0.21	5.5	1.6	2.4
1899	1,960	45.58	51.18	3.24	0.56	0.22	0.35	10.9	4.3	6.7
1900	2,180	46.43	49.97	3.60	0.78	0.23	0.39	16.9	5.1	8.6
1901	[1]200	68.29	29.19	2.52	0.87	0.21	0.55	1.7	0.4	1.1
1901	7,580	37.85	60.19	1.96	0.47	0.16	0.25	35.3	11.9	18.7
1902	[3]410	......	......	......	......	......	......	1.8	0.5	0.9
1903	1,310	36.54	61.51	1.95	0.41	0.08	0.17	5.4	1.1	2.2
1904	2,130	41.67	55.90	2.43	0.38	0.16	0.20	8.0	3.5	4.3
Average[2]	......	44.53	53.10	2.37	0.52	0.16	0.26	......	......	......
Total	18,700	......	......	......	......	......	......	98.0	31.5	51.8
Total pounds	41.2	......	......	......	......	......	......	0.216	0.069	0.114

[1] Summer pruning.

[2] Not including summer prunings.

[3] Sample was not analysed. To compute amount removed, the average of the preceding and following years' analyses were used.

TABLE 3.

Composition of Fruit and Total Plant-Food Removed by It.

YEAR.	Total weight.	CHEMICAL ANALYSIS. Ash.	Nitrogen (N).	Phosphoric acid (P_2O_5).	Potash (K_2O).	AMOUNT REMOVED. Nitrogen (N).	Phosphoric acid (P_2O_5).	Potash (K_2O).
	gms.	%	%	%	%	gms.	gms.	gms.
900	9,130	....	0.17	0.09	0.19	15.5	8.5	17.4
901	8,620	....	....	....	....	14.7	8.0	16.5
902	13,300	....	....	....	....	22.6	12.4	25.4
903	4,910	....	....	....	....	8.3	4.6	9.4
905	19,730	....	....	....	....	33.5	18.4	37.7
Thinnings	....	....	....	....	....	....	....	....
900	660	0.95	0.29	0.12	0.42	1.9	0.8	2.7
902	1,860	....	....	....	....	5.5	2.3	7.7
Total	58,210	....	....	....	....	102.0	55.0	116.8
Total pounds	128.3	....	....	....	....	0.225	0.121	0.258

The fruit was analysed in 1900 only. The analysis includes he pit and pulp.

Elberta peaches and pits analysed the same year were lower n nitrogen and much lower in phosphoric acid—nitrogen, 0.106 ; hosphoric acid, 0.047 ; potash, 0.224 per cent.

TABLE 4.

Composition of Tree and Roots and Plant-Food in Them at Time of Removal.

PORTION OF TREE.	Total weight.	CHEMICAL COMPOSITION. Water.	Organic matter.	Ash.	Nitrogen (N).	Phosphoric acid (P_2O_5).	Potash (K_2O).	Lime (CaO).	AMOUNT REMOVED. Nitrogen (N).	Phosphoric acid (P_2O_5).	Potash (K_2O).	Lime (CaO).
	grams.	%	%	%	%	%	%	%	grams.	gms.	grams.	grams.
Twigs grown in 1905..................	1,190	55.97	40.49	3.54	0.58	0.15	0.24	0.76	6.9	1.8	2.9	9.1
Older twigs below 1 in. diam..........	23,980	38.13	60.72	1.15	0.22	0.08	0.10	0.25	52.8	19.2	24.0	60.0
Trunk & branches..	71,450	27.45	70.65	1.90	0.20	0.08	0.11	0.24	142.9	57.2	78.6	171.5
Roots below 1 in. diam..................	6,580	58.72	39.20	2.08	0.34	0.11	0.13	0.25	22.4	7.2	8.6	16.4
Larger roots..........	21,550	35.33	62.40	*2.27	0.28	0.06	0.16	0.22	60.3	12.9	34.5	47.4
Total	124,750	....	....	....	......	......	......	......	285.3	98.3	148.6	304.4
Total pounds....	275.0	....	....	....	......	......	......	......	0.629	0.217	0.328	0.671

* A small amount of sand still remained in this sample after washing the roots. The figures here used are corrected to a basis of 100 per cent. without the sand.

TABLE 5.

Summary—Ten Years' Growth.

PORTION OF TREE.	Weight.	AMOUNTS REMOVED. Nitrogen (N).	Phosphoric acid (P_2O_5).	Potash (K_2O).	RELATIVE AMOUNTS. Nitrogen (N).	Phosphoric acid (P_2O_5).	Potash (K_2O).
	lbs.	lbs.	lbs.	lbs.			
Wood and roots....................................	316.2	0.845	0.286	0.442	1.	0.34	0.52
Leaves....................................	170.5	1.775	0.351	0.991	1.	0.20	0.56
Fruit....................................	128.3	0.225	0.121	0.258	1.	0.54	1.15
Total....................................	615.0	2.845	0.758	1.691	1.	0.27	0.59
Amount per acre trees set 16x15 feet......	....	516.	138.	307.	....	....	....

TABLE 6.

Computed Total Amounts of Plant-Food Removed and Equivalent Per Acre in Pounds.

YEAR.	No. inches growth.	AMOUNT REMOVED BY ONE TREE. Nitrogen (N).	Phosphoric acid (P_2O_5).	Potash (K_2O).	AMOUNT PER ACRE, TREES 16 X 15 FEET. Nitrogen (N).	Phosphoric acid (P_2O_5).	Potash (K_2O).
	inches.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
96	541	0.026	0.006	0.011	4.7	1.1	2.0
97	2,388	0.102	0.027	0.059	18.5	4.9	10.7
98	4,723	0.233	0.050	0.131	42.3	9.1	23.8
99	5,818	0.364	0.082	0.200	66.1	14.9	36.3
00	6,757	0.369	0.100	0.201	67.0	18.2	36.5
01	11,716	0.535	0.146	0.311	97.1	26.5	56.4
02	6,502	0.365	0.107	0.219	66.2	19.4	39.7
03	5,284	0.299	0.087	0.181	54.3	15.8	32.9
04	3,469	0.263	0.064	0.168	47.7	11.6	30.5
05	2,729	0.289	0.092	0.211	52.5	16.7	38.3
Total	49,927	2.845	0.761	1.692	516.4	138.2	307.1
Average first four years		.181	.041	.100	32.9	7.5	18.2
Average last six years		.353	.099	.199	64.1	18.0	39.5

Total weights.—As will be seen from the tables, the total weight wood produced was 254 pounds, of which 41 pounds were :unings. The total weight of roots was only 62 pounds or about ıe-fourth the weight of the wood growth. The total weight of aves was 171, and of fruit 128 pounds.

Amount of plant-food removed each year.—The number of inches twig growth has been measured each fall as shown in the first lumn of Table 6. To determine the amount of each element moved each year, the amounts removed by the leaves (Table 1) ıd fruit (Table 3) were added to the amount removed by the ood and roots. To determine the latter, the total amount re-.oved by wood and roots in ten years (Table 5) was distributed

throughout the ten years in proportion to the number of inches of new twigs grown each year. The results are shown in Table 6.

There is no positive way of telling the proportion of prunings, wood and roots that grow in any particular year. But it seems to the writer that the total growth of wood and roots is probably in proportion to the number of inches of twig growth. That the enlargement of the trunk was approximately in proportion to the twig growth, was apparent from an examination of the "annual rings." The years when the greatest twig growth occurred were the ones when the annual rings showed most trunk growth.

Amounts of plant-food used by the young and by the mature tree.—It will be seen that there was a gradual increase in the amount of plant-food used each year until the tree had been planted six years. The tree began to bear after it had been set four years, and bore in each of the succeeding six years except 1904. The average amount of plant-food removed per acre during the last six years was 64 pounds of nitrogen, 18 of phosphoric acid, and 40 of potash. If these amounts are taken as representing the plant-food removed by a mature tree, then the amounts used by the young tree are about the following proportions of that used by old trees:

First year	$\frac{1}{10}$
Second year	$\frac{1}{3}$
Third year	$\frac{2}{3}$
Fourth year	Full Amount

When a secondary crop is grown in the orchard for the first few years, this may give some suggestion of the amount of fertilizer required in addition to that used for the crop.

Relative proportions of plant-food used by the young and by the mature tree.—During the first few years, the tree used 0.22 pounds of phosphoric acid and 0.53 pounds of potash for each pound of nitrogen. During the last six years, it used 0.28 pounds of phosphoric acid and 0.62 pounds of potash. This agrees with the general belief that a mature tree requires larger amounts of the minerals in proportion to the nitrogen than are required by a young tree, but the differences are not as great as those usually given.

Relative Amounts of Plant-Food Used.

Year.	Nitrogen.	Phosphoric Acid.	Potash.
1896	1	0.23	0.42
1897	1	0.23	0.58
1898	1	0.21	0.56
1899	1	0.22	0.55
1900	1	0.27	0.54
1901	1	0.27	0.58
1902	1	0.29	0.60
1903	1	0.29	0.61
1904	1	0.24	0.64
1905	1	0.32	0.73

Proportions of plant-food used by different parts of the tree.—Table 5 shows that for each pound of nitrogen, the wood and roots used about one-third of a pound of phosphoric acid and half a pound of potash. The leaves used a little more potash but only one-fifth pound of phosphoric acid, while the fruit used over half a pound of phosphoric acid and over a pound of potash.

Relation of the size of the crop to composition of leaves.—In those years when a crop of fruit was borne the composition of the ash of the leaves was much lower in potash and phosphoric acid, making it appear that a part of the large proportion of these elements found in the fruit were secured by removal from the leaf. The composition of the ash of apple, plum and pear leaves have also been low in potash in years when there was a good fruit crop. When figured on the basis of dry matter, the per cent. of each plant-food was also less on years when there was a large fruit crop.

Composition of Leaves.

	COMPOSITION OF DRY MATTER.			COMPOSITION OF ASH.	
	Nitrogen.	Phosphoric acid (P_2O_5).	Potash (K_2O).	Phosphoric acid (P_2O_5).	Potash (K_2O).
	%	%	%	%	%.
First four years	4.09	0.70	2.12	5.5	17.7
Five years when bearing	2.67	0.55	1.42	4.4	11.2
1904, no crop	3.09	0.66	1.80	5.0	15.8

Stored food in twigs.—On the basis of dry matter, the new twigs contained three to five times as much of the different plant-food constituents as were found in the old wood. It is possible that this represents a large amount of stored food in the twigs and buds. It makes it appear unsafe to assume that the new twigs fairly represent the plant-food used in one year's growth as has been done in some analyses. Another reason why such an assumption is unsafe is that it ignores the growth of the cambium layer throughout the tree. In this tree the new twigs seem to have contained about one-fourth of the total plant-food used in the year's wood growth.

The older twigs below one inch in diameter had practically the same composition as the trunk. The smaller roots contained considerably higher percentages of plant-food than the larger ones.

Composition of Dry Matter in Old and New Wood.

	Organic matter.	Ash.	Nitrogen.	Phosphoric acid.	Potash.	Lime.
	%	%	%	%	%	%
wigs grown in 1905	92.0	8.0	1.32	0.34	0.54	1.73
runk and branches	97.4	2.6	0.28	0.11	0.15	0.33
oots below one inch diameter	95.0	5.0	0.82	0.27	0.31	0.61
arger roots	96 5	3.5	0.43	0.09	0.25	0.34

Proportion of potash and phosphoric acid.—The average amount f potash used is over twice that of phosphoric acid. The results : other Stations have given over three times as much potash as hosphoric acid (Table 7). Most of the fertilizers applied to fruit ees contain a relatively much higher proportion of phosphoric :id. The question naturally arises, as to whether we are not sing relatively too little potash in our tree fertilizers, unless the il is more deficient in phosphoric acid than in potash.

High amount of plant-food used.—There is a wide-spread idea nong fruit-growers that wheat exhausts the soil, but that fruit oes not do so. This theory is doubtless the cause of many of e "starved" orchards that are seen in the Eastern United ates. As will be seen by Table 7 fruit trees use considerably ore nitrogen, a little more phosphoric acid, and about three mes the potash required by a good crop of wheat.

Results at other stations.—The results agree quite closely with ose obtained at other Stations except on potash (Table 7). here are three reasons for this difference.

TABLE 7.

Comparison of Results Obtained at Different Stations—Plant Food Used by One Acre in One Year.

	Nitrogen.	Phosphoric acid.	Potash.
Peach (average last 6 years)	64 lbs.	18 lbs.	40 lbs.
" (New York Exp. Sta.)[1]	75 "	18 "	72 "
" (Germany)[2]	49 "	17 "	75 "
Apple (Cornell)[3]	59 "	17 "	81 "
" (New York Exp. Sta.)[1]	52 "	14 "	55 "
" (Germany)[2]	50 "	10 "	51 "
Average	58 "	16 "	62 "
Wheat—20 bus. + 1½ tons straw[1]	42 "	14 "	20 "

Relative Proportions of Plant-Food Used.

	Nitrogen.	Phosphoric acid.	Potash.
Peach (average last 6 years)	1	0.27	0.63
" (New York Exp. Sta.)[1]	1	0.25	0.97
" (Germany)[2]	1	0.33	1.52
Apple (Cornell)[3]	1	0.29	1.36
Average five different fruits (New York)	1	0.27	1.14
Average—Apple, pear, peach (Germany)	1	0.27	1.33
Wheat and straw	1	0.33	0.48

[1] N. Y. Exp. Sta. Bull. 265, pp. 218, 220.

[2] Exp. Sta. Record, vol. XI., p. 45. The amounts given in the first table are computed for an orchard where the branches just begin to touch between the rows.

[3] Cornell Bull. 226, p. 276.

In each of the trials at other Stations a single year when the trees were bearing a full crop was considered, while here the average of the last six years does not include any large crops. If the tree had given the average yield in the orchard (which is a moderate yield, about 2,000 baskets per acre in the ten years since set), the average amounts removed per acre during the last six years would have been 71 pounds of nitrogen, 22 of phosphoric acid, 48 of potash.

The analyses of wood, leaves and fruit at this Station have shown a relatively lower proportion of potash as compared with nitrogen and phosphoric acid.

At the New York Station only that portion of the wood growth contained in new twigs was considered. At the Cornell Station the prunings were not accounted for, nor was consideration given to the fact that a smaller part of the total wood was grown in the earlier years of the tree's life. Since the wood-growth is relatively low in potash, the results at these Stations probably show a proportionately too large amount of potash. But the results at all Stations point to the same conclusions:

1. Fruit trees use large amounts of plant-food.

2. The proportion of potash used is very much larger than that used by farm crops, and much larger than is usually applied in fertilizers.

3. The proportions of plant-food used are about the same for the different kinds of trees.

Composition of leaves and prunings of various fruit trees.—The results on other trees cannot be completed until the trees are taken out, which should be done after they have reached maturity. Tables 8 and 9 show the average composition of leaves and prunings and of their ash.

TABLE 8.

Average Composition of Leaves of Fruit Trees for Ten Years.

KIND OF TREE.	ANALYSIS.				COMPOSITION OF ASH.	
	Ash.	Nitrogen.	Phosphoric acid (P_2O_5).	Potash (K_2O).	Phosphoric acid (P_2O_5).	Potash (K_2O).
	%	%	%	%		
Apple (Smith cider)	3.78	0.97	0.17	0.72	4.50	19.05
Pear (Lawrence)	4.52	0.98	0.20	0.55	4.42	12.17
" " Dwarf	4.63	0.77	0.22	0.62	4.75	13.39
Plum (Lombard)	5.84	0.78	0.17	1.11	2.91	19.01
" (Newman)	5.02	0.75	0.23	0.86	4.58	17.13
Cherry (Early Richmond)	5.39	0.56	0.14	0.63	2.60	11.69
Quince (Meech's Prolific)	5.00	0.88	0.18	0.70	3.60	14.00
Peach (Crawford's Late)	4.66	1.17	0.23	0.64	4.94	13.73
Average	4.86	0.86	0.19	0.73	4.04	15.02

TABLE 9.

Average Composition of Prunings from Fruit Trees for Ten Years.

KIND OF TREE.	ANALYSIS.				COMPOSITION OF ASH.	
	Ash.	Nitrogen.	Phosphoric acid (P_2O_5).	Potash (K_2O).	Phosphoric acid (P_2O_5).	Potash (K_2O).
	%	%	%	%		
Apple (Smith cider)	1.78	0.41	0.14	0.30	7.86	16.86
Pear (Lawrence)	1.96	0.45	0.19	0.25	9.70	12.76
" " Dwarf	2.68	0.43	0.20	0.31	7.46	11.57
Plum (Lombard)	2.76	0.47	0.18	0.30	6.52	10.87
" (Newman)	1.57	0.35	0.13	0.25	8.28	15.92
Cherry (Early Richmond)	1.90	0.47	0.13	0.22	6.84	11.58
Quince (Meech's Prolific)	2.14	0.40	0.15	0.40	7.01	18.69
Peach (Crawford's Late)	2.37	0.50	0.14	0.24	5.91	10.13
Average	2.15	0.44	0.16	0.28	7.45	13.48
Composition of whole fruit of plums in 1900—						
Lombard						

PLANT-FOOD USED BY ASPARAGUS IN EIGHT YEARS' GROWTH.

The asparagus bed was planted in 1896. The soil is the enn stony loam described on page 192. The yields and the owth of the tops have been weighed and analysed until 1904. he varieties used were: Palmetto, grown on four different fertilizer plots; and Columbian Mammoth white, irrigated and not rigated. Each plot contains 1/216 acres.

Plots 1 and 5 received yard manure at the rate of 20 tons per re per year. Plot 5 was irrigated as required.

Plot 2 received 500 pounds per year of a fertilizer analyzing 5 per cent. nitrogen, 7.7 per cent. available phosphoric acid, id 13.3 per cent. potash.

Plot 3 received the same as plot 2, with the addition of 150 unds each of ground bone and muriate of potash.

Plot 4 received the same as plot 3, with the addition of 200 unds of nitrate of soda after cutting ceased.

The last year the 500 pounds of complete fertilizer was ubled on each of the last three plots, but this could have no ect except on the growth of tops for that year. Plots 3 and 4 ve given a uniformly lower yield than plot 2, but this is undubtedly due to the fact that the soil contains an increasing nount of clay and is more poorly drained as we pass from plots o 4. It can have no effect on the reliability of the following rk, except on the relation of fertilizers to composition.

Table 10 gives the analyses of the tops and the amount of nt-food removed by them on each plot for each year. Tables and **12** give the same data for the edible portion. For this rtion the analyses were made in 1901 only.

TABLE 10.

Weight and Composition of Asparagus Tops and Plant-Fc Removed by Them.

VARIETY AND PLOT.	Year.	Weight.	CHEMICAL ANALYSIS. Water.	Organic matter.	Ash.	Nitrogen (N).	Phosphoric acid (P_2O_5).	Potash (K_2O).	AMOUNT REMOV Nitrogen (N).	Phosphoric acid (P_2O_5).	Potash (K O)
		grams.	%	%	%	%	%	%	gms.	gms.	gm
Palmetto, Plot 1	1896	3,630	60.56	36.75	2.69	1.06	0.22	0.74	38.5	8.0	26
	1897	9,360	52.13	44.40	3.47	0.83	0.17	0.95	77.7	15.9	88
	1898	18,600	71.55	26.26	2.19	0.48	0.07	0.83	89.3	13.0	154
	1899	11,800	57.03	40.38	2.59	0.41	0.10	0.79	48.4	11.8	93
	1900	23,130	62.85	34.59	2.56	0.55	0.13	0.83	127.2	30.1	192
	1901	23,250	74.86	22.78	2.36	0.45	0.11	0.90	104.6	25.6	209.
	1902	13,380	65.35	32.67	1.98	0.34	0.07	0.73	45.5	9.4	97.
	1903	14,060	68.14	29.65	2.21	0.34	0.08	0.72	47.7	11.2	101.
Total eight years	.....	117,210	.....	.....	.....	.....	.....	.....	578.9	125.0	963.
Average eight years	.....	14,650	64.06	33.44	2.51	0.56	0.12	0.81	72.4	15.8	120.
Palmetto, Plot 2	1896	4,650	66.46	30.99	2.55	0.92	0.20	0.74	42.7	9.3	34.4
	1897	8,960	51.57	44.84	3.59	0.82	0.18	1.16	73.5	16.1	103.9
	1898	13,380	68.79	29.21	2.00	0.49	0.07	0.62	65.6	9.4	83.0
	1899	8,390	53.22	43.85	2.93	0.50	0.09	0.69	42.0	7.6	57.9
	1900	19,510	63.17	34.35	2.48	0.59	0.15	0.65	115.1	29.3	126.8
	1901	20,300	73.99	23.69	2.32	0.35	0.05	0.68	71.1	10.2	138.0
	1902	11,790	52.45	45.15	2.40	0.42	0.10	0.54	49.5	11.8	63.7
	1903	11,340	65.94	31.71	2.35	0.40	0.10	0.41	45.4	11.3	46.5
Total eight years	.....	98,320	.....	.....	.....	.....	.....	.....	504.9	105.0	654.2
Average eight years	.....	12,290	61.95	35.47	2.58	0.56	0.12	0.69	63.1	13.1	81.8
Palmetto, Plot 3	1896	3,790	60.89	36.30	2.81	1.06	0.22	0.74	40.1	8.3	28.0
	1897	7,120	50.20	46.02	3.78	0.72	0.16	0.99	51.2	11.4	70.5
	1898	12,930	69.10	28.91	1.99	0.49	0.08	0.72	63.4	10.3	93.1
	1899	8,620	53.09	43.96	2.95	0.45	0.08	0.78	38.8	6.9	67.2
	1900	18,600	63.35	34.27	2.38	0.57	0.13	0.56	106.0	24.2	104.2
	1901	18,600	73.19	24.43	2.38	0.37	0.09	0.79	68.8	16.7	146.9
	1902	9,190	44.97	52.30	2.73	0.52	0.09	0.67	47.8	8.3	61.6
	1903	13,380	67.06	30.54	2.40	0.30	0.05	0.55	40.1	6.7	73.6
Total eight years	.....	92,230	.....	.....	.....	.....	.....	.....	456.2	92.8	645.1
Average eight years	.....	11,530	60.23	37.09	2.68	0.56	0.11	0.73	57.0	11.6	80.6

TABLE 10—Continued.

7eight and Composition of Asparagus Tops and Plant-Food Removed by Them.

VARIETY AND PLOT.	Year.	Weight.	CHEMICAL ANALYSIS. Water.	Organic matter.	Ash.	Nitrogen (N).	Phosphoric acid (P_2O_5).	Potash (K_2O).	AMOUNT REMOVED. Nitrogen (N).	Phosphoric acid (P_2O_5).	Potash (K_2O).
		grams.	%	%	%	%	%	%	gms.	gms.	gms.
	1896	2,060	61.98	35.03	2.99	1.06	0.22	0.71	21.8	4.5	14.6
	1897	5,100	51.52	45.13	3.35	0.73	0.14	1.07	37.3	7.1	54.6
	1898	7,030	68.19	29.62	2.19	0.42	0.04	0.78	29.5	2.8	54.8
lmetto Plot 4	1899	7,600	51.93	44.73	3.34	0.53	0.07	0.57	40.3	5.3	43.3
	1900	13,720	61.42	35.63	2.95	0.77	0.16	0.64	105.6	22.0	87.8
	1901	18,260	73.52	23.79	2.69	0.48	0.09	0.81	87.6	16.4	147.9
	1902	9,190	52.45	45.18	2.37	0.44	0.09	0.61	40.4	8.3	56.1
	1903	14,290	69.32	28.49	2.19	0.31	0.05	0.47	44.3	7.1	67.2
Total eight years	......	77,250	....	....	......	......	......	......	406.8	73.5	526.3
Average eight years	......	9,660	61.29	35.95	2.76	0.59	0.11	0.71	50.9	9.2	65.8
	1896	3,790	66.72	31.05	2.23	0.91	0.21	0.71	34.4	8.0	26.9
	1897	7,000	52.42	44.16	3.42	0.65	0.11	0.96	45.5	7.7	67.2
	1898	10,060	70.91	26.99	2.10	0.45	0.06	0.77	48.0	6.4	82.1
umbian Mammoth White, lot 1	1899	9,530	48.30	49.10	2.60	0.61	0.15	0.89	58.1	14.3	84.8
	1900	10,210	58.83	37.88	3.29	0.69	0.11	0.66	70.4	11.2	67.4
	1901	20,410	72.91	24.50	2.59	0.45	0.12	0.69	91.8	24.5	140.8
	1902	10,090	54.21	43.10	2.69	0.53	0.12	0.72	53.5	12.1	72.6
	1903	11,790	71.61	26.31	2.08	0.36	0.07	0.48	42.4	8.3	56.6
Total eight years	......	83,480	....	....	......	......	......	......	444.1	92.5	598.4
Average eight years	......	10,440	61.99	35.39	2.63	0.58	0.12	0.74	55.5	11.6	74.8
	1896	4,030	....	....	......	......	......	......	....	....	....
	1897	8,820	....	....	......	......	......	......	....	....	....
	1898	14,520	73.24	24.64	2.12	0.47	0.06	0.79	68.2	8.7	114.7
mbian Mammoth White, lot 5	1899	9,070	53.80	43.60	2.60	0.57	0.15	0.93	51.7	13.6	84.4
	1900	13,150	60.27	36.99	2.74	0.61	0.12	0.90	80.2	15.8	118.4
	1901	18,940	74.62	22.85	2.53	0.48	0.12	0.80	90.9	22.7	151.5
	1902	8,960	50.88	46.22	2.90	0.54	0.13	0.87	48.4	11.6	78.0
	1903	11,340	72.69	25.22	2.09	0.29	0.06	0.46	32.9	6.8	52.2
Total six years	......	....	....	....	......	......	......	......	372.3	79.2	599.2
Average six years	......	....	64.25	33.25	2.50	0.49	0.11	0.79	....	....	....

TABLE 11.

Composition of Edible Portion of Asparagus in 1901.

VARIETY AND PLOT.	Water.	Organic matter.	Ash.	Nitrogen (N).	Phosphoric acid (P_2O_5).	[illegible]
			%	%	%	[illegible]
Palmetto, Plot 1	94.90	4.50	0.60	0.21	0.10	[illegible]
" " 2	94.96	4.70	0.61	0.22	0.11	[illegible]
" " 3	95.02	4.38	0.60	0.20	0.10	[illegible]
" " 4	95.03	4.39	0.58	0.20	0.10	0[illegible]
Columbian Mammoth White, Plot 1	94.90	4.51	0.59	0.21	0.09	0[illegible]
" " " " 5	94.79	4.57	0.64	0.22	0.09	0[illegible]
Average	94.89	4.51	0.60	0.21	0.10	0.[illegible]

TABLE 12.

lant-Food Removed by the Edible Portion of Asparagus Based on the Analyses of 1901.

YEAR.	PALMETTO, PLOT 1. Weight.	Nitrogen (N).	Phosphoric acid (P_2O_5).	Potash (K_2O).	PALMETTO, PLOT 2. Weight.	Nitrogen (N).	Phosphoric acid (P_2O_5).	Potash (K_2O).	PALMETTO, PLOT 3. Weight.	Nitrogen (N).	Phosphoric acid (P_2O_5).	Potash (K_2O).
	gms.	gms.	gms.	gms.	gms.	gms.	gms.	gms.	gms.	gms.	gms.	gms.
8..............	1,660	3.5	1.7	4.5	2,210	4.9	2.4	5.5	1,080	2.2	1.1	2.7
9..............	5,590	11.8	5.6	15.1	4,980	11.0	5.5	12.5	4,270	8.5	4.3	10.7
0..............	12,220	25.7	12.2	33.0	11,230	24.7	12.4	28.1	9,550	19.1	9.6	23.9
1..............	14,090	29.6	14.1	38.0	11,430	25.1	12.5	28.6	11,090	22.3	11.1	27.7
2..............	18,470	38.8	18.5	49.9	14,710	32.4	16.2	36.8	13,180	26.4	13.2	33.0
3..............	17,770	37.3	17.8	48.0	15,340	33.7	16.9	38.4	13,370	26.7	13.4	33.4
Total.........	69,800	146.7	69.9	188.5	59,900	131.8	65.9	149.9	52,540	105.2	52.7	131.4
Average.....	11,630	24.5	11.7	31.4	9,980	21.9	11.0	25.0	8,760	17.5	8.8	21.9

YEAR.	PALMETTO, PLOT 4. Weight.	Nitrogen (N).	Phosphoric acid (P_2O_5).	Potash (K_2O).	COLUMBIAN MAMMOTH WHITE, PLOT 1. Weight.	Nitrogen (N).	Phosphoric acid (P_2O_5).	Potash (K_2O).	COLUMBIAN MAMMOTH WHITE, PLOT 5. Weight.	Nitrogen (N).	Phosphoric acid (P_2O_5).	Potash (K_2O).
	gms.	gms.	gms.	gms.	gms.	gms.	gms.	gms.	gms.	gms.	gms.	gms.
1898..............	1,360	2.7	1.4	3.4	1,150	2.4	1.0	2.9	1,520	3.3	1.4	4.0
1899..............	3,230	6.5	3.2	8.1	3,400	7.1	3.1	8.5	3,650	8.1	3.3	9.6
1900..............	8,350	16.7	8.4	20.9	8,240	17.6	7.4	20.6	6,620	14.5	6.0	17.2
1901..............	9,410	18.8	9.4	23.5	8,690	18.3	7.8	21.5	7,360	16.2	6.6	19.1
1902..............	12,960	25.9	13.0	32.4	12,680	26.6	11.4	31.7	12,450	27.4	11.2	32.4
1903..............	13,780	27.6	13.8	34.5	13,670	28.7	12.3	34.2	13,030	28.7	11.7	33.9
Total.........	49,300	98.2	49.2	122.8	47,830	100.7	43.0	119.4	44,670	98.2	40.2	116.2
Average.....	8,220	16.4	8.2	20.5	7,970	16.8	7.2	19.9	7,450	16.4	6.7	19.4

Amount of plant-food removed per acre.—The results of analyses of the six plots agree so remarkably well that it makes little difference which ones are used in computing the amounts removed per acre, except as the total yield varied on different plots. Table 13 gives the pounds of plant-food per acre removed by the Palmetto.

TABLE 13.

Plant-Food Removed Per Acre by the Four Plots of Palme

YEAR.	TOPS.			EDIBLE PORTION.			TOTAL.		
	Nitrogen (N).	Phosphoric acid (P_2O_5).	Potash (K_2O).	Nitrogen (N).	Phosphoric acid (P_2O_5).	Potash (K_2O).	Nitrogen.	Phosphoric acid.	[illegible]
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lt
1896	17.0	3.6	12.4	......	......	......	17.0	3.6	[illegible]
1897	28.4	6.0	37.8	......	......	......	28.4	6.0	[illegible]
1898	29.5	4.2	45.9	1.6	0.8	1.9	31.1	5.0	4
1899	20.7	3.8	31.1	4.5	2.2	5.5	25.2	6.0	3
1900	54.0	12.6	60.8	10.3	5.1	12.6	64.3	17.7	7
1901	39.5	8.2	76.4	11.4	5.6	14.0	50.9	13.8	9
1902	21.8	4.5	33.2	14.7	7.3	18.1	36.5	11.8	5
1903	21.1	4.3	34.4	14.9	7.3	18.4	36.0	11.6	5
	232.0	47.2	332.0	57.4	28.3	70.5	289.4	75.5	402
Average	29.0	5.9	41.5	7.2	3.5	8.8	36.2	9.4	50
Av. last 6 years	......	......	......	......	......	......	40.7	11.0	58

[1] Derived from Tables 10 and 12. Calculated from the $\frac{1}{24}$ acre that was measured.

The edible portion is relatively rich in phosphoric acid, removing over twice as much for each pound of nitrogen or potash as was removed by the tops.

The tops removed over four times as much nitrogen and potash, and about twice as much phosphoric acid as was removed by the edible portion.

Relation of plant-food removed to fertilizer applied.—If the tops are burned on the bed, they leave the phosphoric acid and potash that they contained, so that the amount removed is not large.

	Nitrogen. lbs.	Phosphoric Acid. lbs.	Potash. lbs.
›rage amount removed each year for last six years......	41	11	59
›rage amount removed each year for last six years if tops are burned on bed..	41	4	9
›unt applied on plot 2	23	39	67
" " " " 4	53	69	142

›ince asparagus is usually grown on very sandy soils, and ›e the profit is largely dependent on the size of the stalks, › heavy applications of fertilizer are usually made. Fre›ntly twenty tons of yard manure are used every year, and ›etimes heavy applications of fertilizer are made in addition. ›en manure is not used, applications much larger than those ›en in the table are often made.

›t will be seen that even on plot 4 little more nitrogen was ap›d than was removed. But seventeen times as much phos›ric acid and sixteen times as much potash were applied as ›ld be removed if the tops were burned on the bed. This ›ainly suggests the possibility that we are using relatively ›e of these in our fertilizers than are needed. It seems de›ble that experiments be conducted using heavier applications ›itrogen and less of the minerals; also experiments using ›ogen as a supplement to yard manures.

›ffect of fertilizers on composition.—The average analyses of Palmetto variety on the different plots were as follows:

PLOT.	TOPS.			EDIBLE PORTION.		
	Nitrogen.	Phosphoric acid.	Potash.	Nitrogen.	Phosphoric acid.	Potash.
	%	%	%	%	%	%
....	0.56	0.12	0.81	0.21	0.10	0.27
....	0.56	0.12	0.69	0.22	0.11	0.25
....	0.56	0.11	0.73	0.20	0.10	0.25
....	0.59	0.11	0.71	0.20	0.10	0.25

No striking effect of the different fertilizers is shown ir composition, except that on the manured plot the percentag potash is considerably higher. The larger applications of po on plots 3 and 4, and of nitrogen on plot 4, seem to have slightly increased the percentage of these substances in the t

Composition of the different varieties.—The average composi of the two varieties is practically the same.

VARIETY.	TOPS.			EDIBLE PORTION.		
	Nitrogen.	Phosphoric acid.	Potash.	Nitrogen.	Phosphoric acid.	P[illegible]
	%	%	%	%	%	%
Palmetto	0.57	0.12	0.74	0.21	0.10	0
Columbian Mammoth (white).	0.58	0.12	0.74	0.22	0.09	0

Effect of rainfall on composition.—The tops were lower in tl percentage of nitrogen and higher in the percentage of potash i those years when there was heavy rainfall during the growin season. The irrigated plot also contained a lower percentage (nitrogen and higher percentage of potash than the unirrigatec The relative proportions of nitrogen, etc., in Palmetto tops, com pared with the rainfall, are as follows:

YEAR.	RAINFALL. April to September, inclusive—Inches.	Nitrogen (N).	Phosphoric acid (P_2O_5).	Potash (K_2O).
1896	21.6	1	0.21	0.75
1897	31.2	1	0.21	1.33
1898	25.0	1	0.14	1.56
1899	24.7	1	0.19	1.54
1900	23.1	1	0.23	1.13
1901	33.1	1	0.21	1.93
1902	25.6	1	0.21	1.52
1903	26.9	1	0.20	1.63

Average 4 years, over 25 inches rainfall	1	0.21	1.60
" 4 years, under 25 inches rainfall	1	0.19	1.25
Irrigated plot, 6 years	1	0.22	1.61
Not irrigated, 6 years	1	0.20	1.36

ASPARAGUS BREEDING.

Asparagus growers in New Jersey have practically ceased planting any varieties of asparagus except Palmetto and Argentenil. These two varieties are probably identical. There is a great difference in the quality, and rust-resisting power when seed is secured from different sources. See Annual Report for 1905, page 201. In order to secure the best rust-resistant strain, seed was secured from thirty-six different sources—from a number of seedsmen, from six States, and from France. A number of selections were made from rust-resistant plants in different beds in New Jersey. Some selections were also made from rusted plants for comparison. Selections were made by the writer and by the following growers: C. C. Hulsart, E. T. Ridgway, James C. Hendrickson, John G. Whitall, H. W. Ridgway, and Chas.

Tindall. Plants from this seed were grown this year and a now ready for planting.

A number of the best asparagus growers have been careful selecting seed from good plants for a number of years. Tl selections have been made in the fall. This is a great step i advance, but it does not account for the source of the polle This may have come from a poor plant. If seed is selected fro good plants that are surrounded by good plants, this objection avoided.

It would, of course, be much better if the selection could l made from plants that yield the best crop. The plant th grows the largest top probably yields a good cutting, but n necessarily so. Last spring I met one grower, Mr. Elmer l Clement, of Fairton, who selected some of the best hills durir the cutting season and left these uncut to grow seed (Fig. 3 This is about the highest type of selection that can be carrie out by a farmer. These selected hills blossom in advance of tl field, and are, therefore, fertilized among themselves, so that bot parents must be selected plants. This practice could not readily be carried out when an asparagus hiller is used.

FERTILIZER TRIALS ON SMALL FRUITS AND ASPARAGUS.

Eleven years ago (1896) asparagus, blackberries, raspberrie currants and gooseberries were planted for trials of fertilizer irrigation and varieties.

Asparagus and blackberries.—There are six varieties of aspar gus and blackberries, and two rows of each variety, makin twelve rows of each. Six of these rows are irrigated. The row are 160 feet long ; 5 feet apart in the asparagus, and 7 feet apa in the blackberries.

The soil is a brownish-red, gravelly loam, mapped by the Bu reau of Soils as "Penn Stony Loam." The rows extend down gentle slope. They are crossed by four fertilizer plots. The fir two plots are adjacent and are on quite uniform soil. The thir and fourth plots are on soil that contains considerably more cla and that is not so well drained.

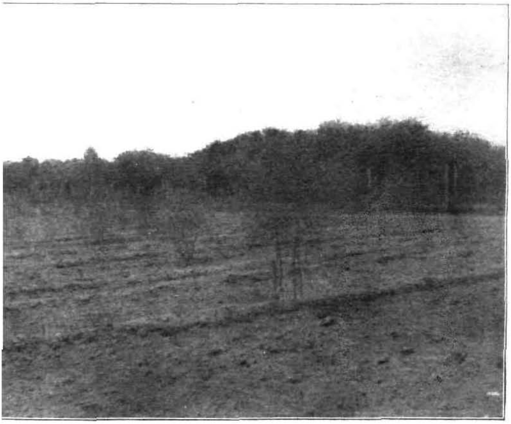


Fig. 3.

The best hills of Asparagus selected during the cutting season and allowed to go to seed.

lot 1 has received an application of yard manure at the rate of 20 tons per acre each fall.

lot 2 has received an application of complete fertilizer every spring at the rate of 500 pounds per acre. This analyses 4.5 per cent. nitrogen, 7.7 per cent. phosphoric acid (available), and 13.3 per cent. potash.

lot 3 has received the same treatment as plot 2, with the addition of 150 pounds each of ground bone and muriate of potash each fall.

ot 4 has received the same treatment as plot 3, with the addition of 200 pounds of nitrate of soda each year after cutting ceased.

In 1905 and 1906 the application of complete fertilizer on ots 2, 3 and 4 was doubled, but all other treatments remained e same.

TABLE 14.

ields of Asparagus and Blackberries with Different Fertilizers.

YEAR.	Asparagus Set in 1896. Each plot one-eighteenth of an acre.				Blackberries Set in 1896. Each plot one-thirteenth of an acre.			
	Plot 1.	Plot 2.	Plot 3.	Plot 4.	Plot 1.	Plot 2.	Plot 3.	Plot 4.
	lbs.	lbs.	lbs.	lbs.	qts.	qts.	qts.	qts.
7	....	....	....	....	53	13	15	6
8	29	30	23	20	249	175	155	108
9	85	80	70	57	138	210	233	210
0	211	193	177	151	420	406	343	329
1	238	216	182	165	120	137	92	100
2	331	304	249	244	44	50	49	73
3	331	303	254	240	225	172	187	210
4	265	244	204	195	49	25	23	22
5	326	295	262	251	118	94	82	84
5	314	292	293	270	116	124	101	100
otal	2,130	1,957	1,714	1,593	1,532	1,406	1,280	1,233
verage yield for 9 years	237	217	190	177	153	140	128	123
verage cost of fertilizer[2]	[2]$1.67	$0.42	$0.69	$0.91	$2.34	$0.59	$0.97	$1.27

In 1906, one variety of blackberries was removed, leaving about 1-16 acre per plot.

This does not allow for the double application of complete fertilizer on plots 2, 3, and 4 of aragus, in 1905 and 1906.

Table 14 gives the yields of asparagus and blackberries or these plots. The manured plot gave the greatest yield in each case and has also given the best quality of product.

On asparagus, the manure has given an average of 20 pounds greater yield than plot 2, at an increased cost of $1.25. Twenty pounds of asparagus is worth about $2.25. Therefore, the manure at $1.50 per ton has not only paid for its greater cost, but has given a net profit of $1 per year, or at the rate of $18 per acre net gain. It has really done better than this, because a better quality of "grass" has been produced, which is worth more per pound. With manure at $2 per ton, the net profit would be $8 per acre. In neither case does this allow for the greater labor in applying manure. This cannot readily be estimated, because it depends on the length of the haul.

On blackberries, the manure gave an average of only four quarts greater yield than plot 2, at an increased cost of $1.75. It was, therefore, not as profitable as the complete fertilizer.

The additional amounts of fertilizer applied on plots 3 and 4 seem to have decreased the yield in both cases, but these plots are on a slightly different kind of soil. The additional amounts do not seem to be of any value on this soil.

Raspberries.—Four plots of raspberries each containing 1/18 acre were treated the same as the preceding plots. In 1904 all but two rows of these were replanted, so that there was little yield that year.

AVERAGE YIELD.	Plot 1.	Plot 2.	Plot 3.	Plot 4.
	qts.	qts.	qts.	qts.
Six crops, 1898-1903	91	87	91	77
Two crops, 1905-1906	110	94	83	68

Currants and gooseberries.—There are four varieties of each of ıese and two rows of each variety, making eight rows of each, ›ur of which are irrigated.

TABLE 15.

Yields of Currants and Gooseberries with Different Fertilizers.

YEAR.	CURRANTS PLANTED IN 1896. EACH PLOT ONE-FORTIETH ACRE.			GOOSEBERRIES PLANTED IN 1896. EACH PLOT ONE-FORTIETH ACRE.		
	Plot 1.	Plot 2.	Plot 3.	Plot 1.	Plot 2.	Plot 3.
	qts.	qts.	qts.	qts.	qts.	qts.
97	20	8	5	51	36	41
98	31	15	18	67	45	51
99	93	89	101	157	107	141
00	149	129	114	321	222	260
01	240	203	215	91	76	76
02	283	233	286	311	175	182
03	158	120	133	316	240	222
04	244	178	230	315	249	265
05	300	236	286	393	265	247
06	154	147	195	314	255	274
Total	1,672	1,358	1,583	2,336	1,670	1,759
Average	167	136	158	234	167	176
Average cost fertilizer	$0.75	$0.17	$0.25	$0.75	$0.17	$0.25

The rows are crossed by three fertilizer plots. The soil on ese three plots is fairly uniform in each case. The currants e on soil like that of asparagus plots 1 and 2. The gooseberes are on soil like that of asparagus plots 3 and 4.

The fertilizer treatment of currants and gooseberries is as folws:

Plot 1 has received yard manure at the rate of 20 tons per acre each fall.

Plot 2 has received 167 pounds each of acid phosphate, ground bone and muriate of potash per acre each fall.

Plot 3 has received the same treatment as plot 2, with the addition of 150 pounds of nitrate of soda, applied each spring.

With both currants and gooseberries, the manure has given the largest yield. It has cost more than either of the other treatments, but has increased the yield enough to more than make up this difference. At a cost of 50 cents more than plot 3, the manure has given an average increase in yield of 9 quarts of currants and 58 quarts of gooseberries.

The treatment given to plot 3 has in each case given second largest yield and has been second in net profit. It cost 8 cents per plot more than plot 2, and gave an average of 22 quarts more currants and 9 quarts more gooseberries.

IRRIGATION OF SMALL FRUITS AND ASPARAGUS.

Half of the rows in each plot, previously described, were irrigated. Since the rows run down the slight slope, the soil on the irrigated and on the unirrigated is alike. Water was applied at from one to three times during the years when it was used. The total application is given in Table 16. One very serious trouble with this work was the danger of putting off irrigation too long in the hope of rain.

Effect of Irrigation on the Yields of Asparagus and Small Fruits Planted in 1896.

YEAR.	ASPARAGUS. Each plot one-ninth acre.			BLACKBERRIES. Each plot one-sixth acre.			RASPBERRIES. Each plot one-twenty-seventh acre.			CURRANTS. Each plot three-twentieths acre.			GOOSEBERRIES. Each plot three-twentieths acre.		
	Inches water.	Yield irrigated.	Yield unirrigated.	Inches water.	Yield irrigated.	Yield unirrigated.	Inches water.	Yield irrigated.	Yield unirrigated.	Inches water.	Yield irrigated.	Yield unirrigated.	Inches water.	Yield irrigated.	Yield unirrigated.
		lbs.	lbs.		qts.	qts.		qts.	qts.		qts.	qts.		qts.	qts.
1896	....	....	....	1.80	....	....	3.00	....	....	1.37	....	....	1.37	....	....
1897	1.42	........*	....	1.26	36	50	2.35	6	4	1.37	23	11	1.37	77	50
1898	*2.40	52	50	3.46	387	298	2.96	43	30	*2.22	39	26	2.90	84	78
1899	1.45	150	142	1.50	499	292	2.00	82	74	0.85	154	129	0.85	196	208
1900	*2.75	361	371	2.00	691	797	2.75	60	62	*1.00	211	182	1.00	420	382
1901	1.50	401	400	1.00	236	213	2.00	42	43	2.75	342	316	2.75	130	113
1902	0.75	553	575	1.00	110	106	2.00	51	54	2.00	407	395	2.00	329	339
1903	2.00	546	583	3.00	338	456	3.00	80	92	3.00	212	198	3.00	397	381
1904	....	436	471	....	64	54	....	65	57	....	344	309	....	414	415
1905	*4.45	544	591	4.80	216	163	4.00	52	42	*2.00	415	408	2.00	455	450
1906	....	583	586	....	219	222	....	56	43	....	233	263	....	442	400
Total	16.72	3,626	3,768	19.82	2,796	2,652	24.06	537	501	16.56	2,380	2,237	17.24	2,944	2,816
Average †	....	403	419	....	279	265	....	54	50	....	238	224	....	294	281

* Water applied so late in season as to benefit the next year's crop only.

† Average for the number of years in bearing.

In no case has the irrigation given a sufficient increase in yield to make it profitable. This does not, however, indicate that irrigation cannot be profitably employed on some soils in the State. During the past summer water was used with great profit on strawberries at Port Norris. In this case, the berries were planted on reclaimed marsh land. When the dry weather was greatly injuring the strawberry crop on upland, the water was let into the drainage ditches with good results.

VARIETIES OF SMALL FRUITS AND ASPARAGUS.

The Palmetto asparagus is so far in the lead of other varieties that they should all be discarded as they have been by most of the growers (Table 17). The Argentenil is also grown here, but it is younger than the Palmetto. As stated elsewhere, it is probable that these two varieties are identical.

TABLE 17.

Yields of Varieties of Asparagus Planted in 1896—Each Variety One-Twenty-seventh Acre.

YEAR.	Barr's Mammoth.	Elmira.	Columbian Mammoth White.	Palmetto.	Conover's Colossal.	Giant Brunswick.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1898	13	26	18	24	15	....
1899	39	58	53	81	49	9
1900	111	134	121	171	121	75
1901	119	144	116	199	143	79
1902	157	200	184	257	189	142
1903	158	197	184	262	173	160
1904	118	142	149	220	137	142
1905	160	172	177	278	169	180
1906	155	177	171	288	177	201
Total	1,030	1,246	1,173	1,780	1,173	988

TABLE 18.

Yields of Varieties of Blackberries Planted in 1896—Each Variety One-Nineteenth Acre.

YEAR.	Early Harvest.	Wilson, Jr.	Erie.	Agawam.	Taylor.	Eldorado.
	qts.	qts.	qts.	qts.	qts.	qts.
....	8	28	21	7	3	20
....	134	98	120	144	81	108
....	104	88	109	211	106	173
....	271	216	307	204	240	251
....	112	48	72	49	60	108
....	27	38	39	19	29	64
....	164	98	158	87	122	161
....	....	7	6	38	48	21
....	16	46	77	79	74	86
....	95	*	123	85	67	70
Total........................	931	667	1033	923	880	1062
Average..................	93	74	103	92	83	106
" before 1904...	116	88	118	103	91	126

lson, Jr., removed spring of 1906.

TABLE 19.

Yields of Varieties of Gooseberries and Currants Set in 1896—Each Variety One-Forty-eighth Acre.

YEAR.	CURRANTS.				GOOSEBERRIES.			
	Fay's Prolific.	Red Dutch.	Victoria.	White Grape.	Downing.	Columbus.	Houghton.	Triumph.
1897	3	6	9	8	39	2	86	1
1898	1	20	21	8	41	8	110	5
1899	32	83	82	30	136	53	176	40
1900	58	141	145	36	289	114	301	98
1901	117	225	196	120	37	45	112	49
1902	126	270	248	163	321	65	212	70
1903	83	171	140	17	256	127	298	95
1904	80	285	251	37	187	137	375	129
1905	136	289	262	217	297	163	306	136
1906	117	152	149	77	264	174	280	123
Total	753	1642	1503	713	1867	888	2256	746
Average	75	164	150	71	186	91	231	75

The winter of 1904 greatly damaged the blackberries. The Wilson, Jr., were most severely injured. The Ward blackberry is also grown, but being set later cannot be compared with these varieties.

The Red Dutch and Victoria currants have given over double the yields produced by the Fay's Prolific and White Grape.

The Downing and Houghton gooseberries have produced over double the yield given by the Columbus and Triumph. The bushes are also more vigorous, but the latter varieties produce very much larger fruit.

TIME OF YEAR THAT FRUIT TREES MAKE THEIR GROWTH.

The time of year that a tree makes its twig growth is thought be the time when it is most in need of tillage. In order to termine when the different trees do make their twig growth, ne large limbs were marked on one average tree of each kind; d at nine dates during the summer all the new growth was asured.

The apple and plum had made nearly half of their twig owth by May 18th, and made comparatively little growth er June 12th. The pear nearly completed its growth by June th, and the cherry by July 10th.

So far as this has a bearing on the tillage question, it suggests importance of early tillage, as early as the ground is fit—ore the corn is planted. It also suggests that tillage should p early.

TABLE 20

ne of Year that Trees at New Brunswick Make Their Twig Growth.

DATE.	INCHES OF NEW TWIG GROWTH.				
	Smith Cider Apple.	Lawrence Pear.	Lawrence Pear (Dwarf).	Early Richmond Cherry.	Newman Plum.
18	664	....	....	....	499
21	....	208	87	418	....
e 1	891	273	108	524	687
12	1,091	429	175	757	757
26	1,157	489	190	908	803
10	1,174	523	205	1,192	818
24	1,197	544	207	1,216	826
. 7	1,231	552	211	1,231	828
				67	828

TWO SERIOUS DISEASES IN 1906.

Blight (*Bacillus amylovorus*).—A very serious and unusual outbreak of this disease occurred in the State this year. It is known as twig-blight, blossom-blight, fire-blight, pear-blight, and when it occurs on the trunks and large limbs it is called body-blight.

It has been the great enemy of Bartlett pear-growers for years. Because of it, only a few growers are successful in growing this variety of pears in this State. The Kieffer is not so seriously affected. There is generally more or less of it in apple orchards. In the form of body-blight, I saw one young orchard in Sussex county that had been almost ruined. It has not usually attracted much attention in apple orchards.

Last spring, about blossoming time, it became extremely severe on apples in the southern two-thirds of the State. On many varieties the larger part of the blossoms were killed. In some cases practically the entire crop of some varieties was lost. Later considerable twig-blight followed.

"*Cloudiness*" *of pears*.—What causes the rusty coat or "cloudiness" of the Kieffer pear, is a perennial question in New Jersey.[1] This year there has been a great deal of the same trouble with the Bartletts.

There are, at least, three distinct causes that lead to the rusty appearance: 1, frost; 2, too strong a spray; 3, fungous diseases. Anything that injures the skin of the fruit is likely to result in the growth of a corky layer of skin that has the rusty color. When one becomes familiar with the characteristics of the injuries from each of the three causes, they may be readily distinguished, but to one who is not familiar with them they all pass as one thing. The rusty appearance of apples is sometimes attributed to too strong a spray, when the trouble is really due to not having sprayed thoroughly enough to control the diseases.

Dr. Halsted has suggested that the "cloudiness" of the Kieffer may be due to characteristics inherited from its Chinese Sand Pear parent.

[1] N. J. State Hort. Soc. Reports, 1901, p. 88; 1902, pp. 106, 107; 1903, pp. 59-63.

In one case of Bartlett pears, that was looked up this year, the trouble was undoubtedly due to the after-effects of an attack of the apple-scab fungus (*Venturia inæqualis*). When this disease has run its course, the diseased tissue peels off, and leaves a rusty-colored skin. I found this same effect to be almost universal in the poorly-sprayed apple orchards in Orleans county, N. Y., in 1904.[1] This disease can readily be controlled by spraying.

Sometimes too strong a spray is used. This may injure the skin and cause a rusty color. About 4 pounds of copper sulphate to 50 gallons of water for spraying just before and just after blossoming, with at least twice the lime required by the potassium ferrocyanide test, is not likely to cause injury. In this climate, I think that a third spraying should not contain over three pounds of copper sulphate.

This question is not yet fully settled, but I am of the opinion that the greater part of the "cloudiness" is due to the after-effects of fungous diseases, probably partly caused by other diseases than the scab. Certainly some of it is due to fungous diseases. The almost universal experience that it is worst in shaded parts of a tree and in trees with dense tops strengthens this view.

SPRAYING.

San José Scale.—Apples, plums, pears, peaches and currants at the Station were given a thorough application of lime, salt and sulphur in the spring. This was very successful. Considerable fruit was marked by scale in 1905, but on only a few trees was any marked this year. The peaches were unsprayed the preceding year and were very badly infested, but there is little live scale on the trees now.

The gas sprayer was rusted on the inside to such an extent that the flakes of iron continually stopped up the nozzles. This may have been the fault of the care given it, rather than the fault of the machine. This delayed the spraying until we secured a new hand-pump. Some of the buds of peaches and

[1] Cornell University, Bull. 226 p. 336.

plums were then beginning to show the color of the blossoms. A part of the blossom buds were killed on a few of the more advanced plum trees. Some of the blossoms and some twigs on peach trees were injured.

The mixture was boiled with steam and was prepared by the formula:

15 pounds of flowers of sulphur,
15 to 25 " " lime (according to quality),
8 " " salt (omitted in part of the work),
45 gal. of water.

With one man to prepare the mixture, one to pump and two to spray, we applied 320 gallons per day.

Brown rot and curculio on plums.—May 8th, just after blossoming, 19 plum trees were sprayed with Bordeaux mixture, using 2 pounds of copper sulphate to 50 gallons of water, and twice the lime required by the potassium ferrocyanide test. To this was added 4 pounds of lead arsenate. The spraying was repeated May 21st.

There seemed to be a few less curculio marks on these trees than on the unsprayed ones. The brown rot was just as severe as where not sprayed. The spray burned many holes in the leaves, and caused many leaves to fall.

Apples and pears were sprayed May 8th–10th and May 21st–22d, using 4 pounds of copper sulphate to 50 gallons of water and twice the lime required by the potassium ferrocyanide test. To this was added one-half pound of Paris green. Very heavy applications were made. The last spraying caused some rusting of the fruit and some spotting of the leaves. I believe that a still further reduction of the amount of copper sulphate should be made in the later sprayings. Three or even two pounds with two or three times as much lime is often used by growers. It seems to be enough to control the disease, and is not so likely to "russet" the fruit. If an application is made thoroughly with one of the weaker sprays, there may be nearly as much of the copper on the trees as when a less thorough application with a strong mixture is made, but the distribution is better.

Egg plants.—Half of a row of egg plants was sprayed four times, using 4 pounds of copper sulphate to 50 gallons of water

and twice the lime required by test, with 4 pounds of arsenate of lead. The yields were not recorded, but the sprayed plants made a much better growth early in the season, and produced more early fruit and apparently a considerably greater crop. It undoubtedly pays growers to spray egg plants for the blight, flea beetles and potato "bugs," but comparatively few are now spraying.

Tomatoes.—This crop was sprayed in three different ways.

1. Sprayed in seed bed only.
2. Sprayed in field only.
3. Sprayed in seed bed and in field.
4. Unsprayed.

The same spray mixture that was applied on egg plants was used, except that when spraying in the seed bed only half the amount of copper sulphate was used.

Little difference was apparent between sprayed and unsprayed plants until the middle of August. At this time the unsprayed vines lost a large part of their leaves and showed a marked contrast with the sprayed ones. The fruit picked after this time was much firmer and better from the sprayed plants than from the unsprayed.

Mr. Asa Bitters, of Roadstown, Cumberland county, carried on a test of spraying tomatoes that were grown for the canning factory. Twice during the season I visited his farm to give suggestions on the work, and am satisfied that all the work was done in a careful manner. The following is a summary of Mr. Bitters' report:

The seed was sown April 16th. Plants for the first three plots were sprayed in the seed bed May 16th, 24th and 30th. For this spraying in the seed bed the spray was prepared at the rate of 2 pounds of copper sulphate and double the lime required by the potassium ferrocyanide test to 50 gallons of water. For spraying in the field 4 pounds of copper sulphate were used. In the first two applications Paris green was used for the green tomato worms and potato bugs. The plants on plots 1 and 2 were set in the field June 2d, those on plots 3 and 4 were set on May 31st. These were badly beaten down by a heavy rain the night

after setting, and are probably not comparable with plots 1 a 2. The last cultivation was given on July 19th. The yie were as follows:

	No. plants.	YIELD IN BUSHEL BASKETS					
		Aug. 15.	Aug. 22.	Aug. 29.	Sept. 7.	Sept. 12.	Total
1. Sprayed in seed bed only	364	2	14	14	18	2	[illegible]
2. Sprayed July 7 and 21	364	2	11	17½	16	2	4
3. Sprayed June 13, 25, July 7 and 21	728	3	26	35	36	5	1
4. Unsprayed	728	3	26	22	30	4	8

From this it would appear that four applications in the fie on plants that had been sprayed in seed bed increased the yie from 85 to 105 baskets, or 24 per cent. The results on the fir two plots are somewhat contradictory.

The spraying was done with a knapsack sprayer. To do regu lar spraying a four-row potato sprayer should be used. Wit such a machine the cost of each application, including material labor and use of sprayer, is about $1 to $1.50 per acre.

Cantaloupes.—This crop was sprayed with the same mixtur that was used on egg plants (p. 226). The unsprayed plant began to blight by the middle of August, and the leaves were practically all dead by the middle of September. The sprayed plants also blighted, but remained green about a week longer. This allowed a considerably larger proportion of the crop to ripen naturally. The last spraying was given August 6th. To be entirely successful, later spraying would have been necessary. The vines would be in the way of later spraying with a regular field sprayer, but it might be possible to spray by driving through about every ten rows and using long hose, somewhat on the plan given in Farmers' Bull. 231, p. 14.

SPRAYING TOMATOES AND STRAWBERRIES IN BLOOM.

Tomatoes.—Since tomatoes must be sprayed while in bloom, if regularly sprayed while in the greenhouse or field, two trials were made to see what effect Bordeaux mixture would have on the setting of fruit.

Nov. 11.—Tomatoes in the greenhouse were sprayed with Bordeaux mixture at the rate of 3 pounds of copper sulphate and 2 pounds of lime to 50 gallons of water (2:4:50 is a better formula for greenhouse tomatoes). Three hundred blossoms on ninety-six clusters had previously been marked by tying strings around their stems (pedicels). The blossoms were divided into three different ages:

100 young blossoms from just opening to half open,
100 in the middle of the blossoming period,
100 old blossoms.

Dec. 12.—The number of fruits set were counted, also the total number of blossoms and fruit on the ninety-six clusters. The results were as follows:

	No. blossoms.	No. fruits set.	Per cent. set.
Young blossoms, sprayed	100	45	45
Middle-aged blossoms, sprayed	100	59	59
Old blossoms, sprayed	100	65	65
Average	....	....	56
Total other blossoms, same clusters, mostly opened before and after spraying	353	143	41

The test was repeated on 100 clusters, November 27th. At th: time the first cluster had set full. The later clusters were nc setting so large a per cent. The results were as follows:

	No. blossoms.	No. fruits set.	Per cent. set.
Young blossoms, sprayed	100	10	10
Middle-aged blossoms, sprayed	100	19	19
Old blossoms, sprayed	100	18	18
Average	....	....	16
Total other blossoms, on same clusters, mostly opened before and after spraying	450	120	27
Average both trials, sprayed	....	....	36
Average, both trials, unsprayed	....	....	34

The results are somewhat contradictory, but it does not appear as if the spraying had any serious effect on the setting of the fruit. In the second trial the spray was deficient in lime.

Strawberries.—It is often desirable to spray strawberries for the leaf-spot and other troubles when they are in bloom.

May 15th, a short row of strawberries was divided into three parts, and blossoms that were open on each part were marked with strings. Plot 1 was sprayed with Bordeaux mixture (2:3:50), 2 pounds of copper sulphate and 3 pounds of lime to 50 gallons of water. This was twice the amount of lime required to neutralize the spray. Plot 2 was unsprayed. Plot 3 was sprayed with 4:6:50 formula.

May 31st, the fruits were counted.

	No. blossoms marked.	Per cent. of perfect fruit.	Per cent not perfect.	Per cent. not set.
Plot 1, sprayed (2:3:50)	127	36	31	33
" 2, unsprayed	166	51	22	27
" 3, sprayed (4:6:50)	179	38	27	35

May 20th, the trial was repeated. The per cent. of fruit set was determined on June 7th.

	No. blossoms marked.	Per cent. of perfect fruit.	Per cent. not perfect.	Per cent. not set.
Plot 1, sprayed (2:3:50)	118	63	12	25
" 2, unsprayed	120	47	14	39
" 3, sprayed (4:6:50)	143	37	17	46

A fourth plot was sprayed with 6 pounds of copper sulphate, but the ground on this plot was hard, and the plants were badly damaged by dry weather just after spraying.

The results are not uniform, but they do not seem to show that the spraying caused much, if any, injury.

METHODS OF MAKING BORDEAUX MIXTURE.

There are about twenty rather recent bulletins from Experiment Stations and from the Department of Agriculture that tell how to prepare Bordeaux mixture. I believe that there are only two[1] that do not insist that both the copper sulphate and the lime should be diluted before they are brought together. The com-

[1]Cornell Bull. No. 217, New Jersey Bull. No. 194

mon direction is to put half the water with each of these and then pour them together into a third barrel. This sounds like a simple matter, but when much spraying has to be done it requires considerable extra time and trouble unless elevated tanks are used. Very few farmers have the elevated tanks or will go to the expense of getting them. Neither do they go to the trouble of diluting both substances. They find this too bothersome. I have been surprised to see how many good fruit-growers put the concentrated solutions together. When a simple and yet correct way of preparing the mixture is given to them, they stand ready to accept it. Fortunately there is such a simple method that is just as good as elevated tanks. It is simply this: *Have the tank nearly full of water containing either the copper sulphate or the lime before adding the other.* The wrong way is to put the concentrated solutions together before adding the water.

One of the farmers' institute lectures, last year, called attention to the recommendation by an Experiment Station that the copper sulphate must be added last. Trials of this have shown that it is slightly better to add the lime last. It is also more convenient when the amount of lime required is determined by the potassium ferrocyanide test.

So far as is known, the only difference as a result of the method of preparation is in the mechanical condition of the spray. If not properly made, a heavy, curdled mass is formed that clogs the nozzles and does not stay in suspension well.

When two particles of water come together, one containing copper sulphate and the other lime, these substances unite. If the solutions are concentrated, a large, heavy mass is formed. But if the solutions are dilute, only small particles of the new substance are formed. These small particles remain suspended in the water and make a good mixture. Theoretically, it would seem that if either substance were dilute it would limit the size of the particles formed and so make as good a mixture as if both were dilute. Numerous trials have shown that this is the case.

Many trials of the four methods of preparation were made in farmers' institutes and more accurate ones were made in the laboratory. Bordeaux was prepared by the 4:4:50 formula,

using stock solutions which contained 2 pounds of copper sulphate and 2 pounds of lime per gallon of water. The mixture was prepared in tall glass cylinders. The slower the particles settled, the better the mixture. The mixture was prepared—(1) by putting the concentrated solutions together and filling the cylinder with water, (2) by putting the copper sulphate in the cylinder, then filling nearly full of water and last adding the concentrated lime, (3) by putting the lime and water together and then adding the concentrated copper sulphate, and (4) by diluting each substance with half the water, and pouring simultaneously into a third cylinder. The following are typical results:

	Beginning.	HEIGHT OF COLUMN IN INCHES AT END OF—			
		30 min.	1 hour.	6 hours.	24 hours.
Both solutions concentrated	22	11	5	3	....
Copper sulphate, diluted	22	21¾	17½	11	9
Lime diluted	22	21	15	7	6½
Both solutions diluted	22	20	15	8	7

One pound of the lime used in this trial would neutralize two pounds of copper sulphate. In two trials, when only half as much lime was used, the third method was as good as the second. Since an excess of lime is used in regular spraying, as in the above experiment, the second method is a little better than the third. About twice as much lime is ordinarily used as is required to neutralize the copper sulphate. If this lime is put in a barrel of water, it may be said to be twice as strong a solution as that formed when the copper sulphate is diluted with the barrel of water. Since the fineness of the particles depends on the extent of the dilution of either substance, the second method

is somewhat better, but any of the last three methods gives a satisfactory mixture.

The more dilute the copper sulphate, the better the resulting mixture. Several trials of this were made. The copper sulphate was diluted with $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$, and all the water before adding the concentrated lime and remainder of the water.

PROPORTION OF WATER ADDED BEFORE LIME WAS ADDED.	HEIGHT OF THE COLUMN IN INCHES AT THE END OF—		
	Beginning.	45 minutes.	$5\frac{1}{4}$ hours.
One-fourth	$5\frac{1}{2}$	$3\frac{1}{2}$	$2\frac{5}{8}$
One half	$5\frac{1}{2}$	$4\frac{3}{4}$	$2\frac{3}{4}$
Three-fourths	$5\frac{1}{2}$	$4\frac{7}{8}$	$3\frac{1}{2}$
All	$5\frac{1}{2}$	5	$3\frac{5}{8}$

STOCK SOLUTIONS OF COPPER SULPHATE.

Three different methods for making stock solutions have been recommended. One or two pounds of copper sulphate may be dissolved in each gallon of water. Or a saturated solution may be formed, each gallon of which is supposed to contain 3 pounds of copper sulphate. It was the writer's intention to recommend the latter method, but on evaporating some of such a solution it was found to contain less than $2\frac{1}{2}$ pounds per gallon. This is an error of 19 per cent., which is decidedly too great.

The method was based on solubility tables. Storer[1] gives the solubility of the crystalline salt as follows:

Temperature.	Parts soluble in 100 parts of water.	Equivalent in ounces per gallon.
50° F	36.95	47
68° F	42.31	54
86° F	48.81	59

[1] Dictionary of Solubilities, p. 596.

At ordinary temperatures, it would, therefore, appear that a ;allon of water could contain over 3 pounds of copper sulphate. 3ut there are two points to be considered: 1. When a gallon of vater has dissolved 3 pounds of salt, it is much more than a gal-on. 2. Commercial copper sulphate does not seem to dissolve eadily as much as the tables indicate.

Expansion of water when copper sulphate dissolves.—From the ormula of copper sulphate, $CuSO_4 + 5H_2O$, it is evident that it s 36 per cent. water. When 3 pounds are dissolved, over a pint f water of crystallization is liberated. The water expands more han this amount.

1. May 31st, 1906, 43 grams of the crystalline commercial opper sulphate was put in a flask, with 100 cc. of distilled water.

2. The same trial was repeated with city water. The flasks vere corked, and were shaken from time to time.

June 13th, Temperature of solution, 73° F.
Volume of solution, first flask, 116½ cc.
" " " second flask, 117 cc.
Undissolved copper sulphate, first flask, 4.1 grams.
Parts per 100 dissolved, 38.9 grams.
Undissolved copper sulphate, second flask, 3.8 grams.
Parts per 100 dissolved, 39.2 grams.

In the average of the two trials, the volume of water was in-reased by as many cc. as 43 per cent. of the number of grams f copper sulphate. If 3 pounds did dissolve in a gallon of ater there would, therefore, be 1 gallon, 1¼ pints.

Amount of copper sulphate in a saturated solution.—In the above xperiment, the solubility was also much below that given in the hemical tables. In order to see how much is dissolved under ommercial conditions, 237½ cc. of a saturated solution was vaporated. It was taken from a pail that had contained such a olution for several months. Its sides were coated with crystals, nd a bag of crystals was suspended in the solution. The same

amount was also evaporated from a stock solution (one poun gallon of water) that we were then using in our own spra work:

DATE.	SOLUTION.	Temperature.	Amount evaporated.	Crystals copper sulphate left.	Equivalent oz. per gallon.	
May 22	Saturated	66° F.	237½ cc.	68.7 gms.	38.8	1
" 31	Saturated Filtered	71° F.	" "	75.5 "	42.6	1
" 31	Saturated	71° F.	" "	76.1 "	43.0	1
" 31	1 lb. per gal		" "	27.8 "	15.4	

If this saturated stock solution at a temperature of 66° assumed to contain 3 pounds per gallon, its use results i error of 19 per cent. That is, if one prepared a spray supp to contain 6 pounds of copper sulphate to 50 gallons of wate would really have only 4 lbs., 14 oz. Much spraying is when the temperature of the water is considerably below 66 It therefore seems that the method of using a saturated s solution is too inaccurate.[1]

The objection to a solution that contains 1 pound per gall water is that it gets stronger as it evaporates. It would hav evaporate 5 per cent. to correct the error due to the increas volume when the copper sulphate dissolved. The stock solu which we were using in our spraying had evaporated enoug that it gave an error of 3.7 per cent. If such a solution is for a long time, the surface of the water can be marked and barrel filled to this point before using.

[1] N. Y. Exp. Sta. Bull. 243, p. 327; Iowa Exp. Sta. Bull. 85, p. 47.

THE FORCING OF TOMATOES.

General methods of culture used.—The following are some of ie more important dates in the growth of the tomato crop in the ast winter (1905–6):

Aug. 14, planted seed in three-inch pots.
" 21, plants coming up.
Sept. 4, thinned to two plants per pot.
" 11, repotted in four-inch pots.
" 28, planted in beds.
Oct. 7, first blossoms.
Dec. 16, first ripe fruit.
Apr. 17, about half of plants removed.
May 8, remaining plants removed. The plants might all have been removed about the middle of April, if the beds had been needed.

The soil used was a compost containing about one-fourth yard ıanure and three-fourths sand and old, greenhouse soil. Manure ater was applied about once a week after the plants began to ear. The benches were 10 inches deep. They were packed full ' soil. This eventually settled, so that there remained about 8 ıches of soil. The side benches were 8½ inches deep. The il was watered about twice a week and the surface was tilled bout once a week.

The house was fumigated with tobacco several times, but this ad little effect. The record of fumigation with hydrocyanic id is given on page 242. The plants were sprayed twice with ordeaux mixture, and several times with ammonical copper carnate. The soil was found to be infested with nematode worms. hese became very severe during the latter part of the season. hey probably delayed the maturing of the fruit and made the st pickings of poor quality.

Varieties of tomatoes for forcing.—Eleven different commercial ırieties were grown. Eight varieties were also selected for trial om the crosses produced by Dr. Halsted. The origin of these shown in Table 21, *i. e.*, Magnus-ponderosa is a cross between agnus and Ponderosa.

TABLE 21.

Average Yields of Tomatoes, Ten Plants of Each Variety.

VARIETY.	Rows.	Days to first fruit.*	Total number fruits.	Total ounces.	Average weight per fruit.	Average yield per square foot.	Shape.
Center Bed—					oz.	lbs.	
Frogmore's Selected	2, 30	85	379	981	2.6	3.07	Good.
Stone	5, 27	91	211	816	3.9	2.55	Rough.
Lorillard	7, 25	98	262	639	2.4	2.00	Fairly smoo
Eclipse	10, 22	91	300	729	2.4	2.28	" "
Perfection	12, 20	91	224	719	3.2	2.25	Rough.
Best of All	15, 17	94	318	665	2.1	2.08	"
Elongated Sparks Earliana (5 plants)	16	80	114	291	2.6	1.82	Fairly smoo
Magnus-Ponderosa	3, 29	91	161	643	4.0	2.01	Rough.
Ponderosa-Marvel	4, 28	85	185	680	3.7	2.12	"
Arcadia-Cumberland	6, 26	80	182	536	2.9	1.67	"
Station Yellow	8, 24	94	192	423	2.2	1.32	Fairly smoo
Magnus-Dwarf Champion	9, 23	94	281	782	2.8	2.44	" "
Earliana-Freedom	11, 21	80	289	541	1.9	1.69	" "
Crimson Cushion-Mayflower	13, 19	80	307	711	2.3	2.22	" "
Arcadia-Earliana	14, 18	80	204	591	2.9	1.85	Rough.
End rows	1, 31	85	191	508	2.7	1.59	....

Total Yield .... 641.5 lbs.
Total area .... 310.0 sq. ft.
Average yield per square foot .... 2.07 lbs.
Average value per square foot .... 57c.

VARIETY.	Rows.	Days to first fruit.*	Total number fruits.	Total ounces.	Average weight per fruit.	Average yield per square foot.	Shape.
Side Bench—							
Best of All	1, 4	105	105	243	2.3	....	Rough.
Lester's Prolific	2, 5	91	280	656	2.3	....	Good.
Beauty	3, 6	101	126	360	2.9	....	Fairly smoo
Early Minnesota (5 plants)	7	115	48	78	1.6	....	" "
Mixed (13 plants)	....	....	168	315	1.9	....	....

*The number of days to first fruit is counted from the time after being set in the bed. T might have been shortened if the plants had been allowed to grow in pots for a longer time.

Two rows of five plants each were grown of each variety, ex-
t of Elongated Sparks Earliana and Early Minnesota, of
ich one row each were grown. In the center bench, the north
(No. 1) and the south row (No. 31) were planted as protect-
rows. The varieties were planted in rows 2 to 16, and were
eated in the reverse order in rows 17 to 30. Table 21 gives
sums of the yields of the duplicate rows. Each plant was
owed 2 square feet of space. The average yield was 2.07
inds per square foot, or 4.14 pounds per plant. A part of one
e bench was planted with tomatoes. A single row was grown
h plants 10 inches apart.

The Frogmore's Selected made the best showing in this trial.
e fruit averages a little small, but the large yield and the good
ipe more than made up for this. It is a very rank-growing
iety.

The Lester's Prolific appeared very promising, but was grown
a side bench, so that no reliable comparison can be made
h the Frogmore's.

The Mangus-Dwarf Champion, a cross produced by Dr. Hal-
l, made an excellent showing. The fruit is a very attractive
ık-red.

Stone gave a good yield, but the fruit was rather rough.

In previous years the Lorillard and Best of All have done
atively better than this year.

Hand-pollination compared with self-pollination.—On 17 plants
ry other cluster was pollinated, beginning with the first clus-
on 9 plants and with the second cluster on 8 plants. The
aining clusters were not pollinated. The hand-pollination
e 48 per cent. more fruits and gave a slightly smaller propor-
n of ill-shaped fruits.

	Hand pollinated.	Not pollinated.
Number of clusters	39	43
" " fruits	62	42
Per cent. of ill-shaped fruits	15	19

Method of marketing.—At twelve different dates during the
nter, tomatoes were shipped to New York City to be sold by
commission firm of Archdeacon & Co.

They were shipped in three and six-pound, wooden-handled grape baskets. These baskets cost $3\frac{1}{2}$ cents each. Tomatoes were wrapped in a cheap, but attractive, quality of tissue paper. It was found that they fitted into the basket much better when wrapped so as to give a rectangular package. This was accomplished as follows: Fold one side over as if the tomato were a square box, fold the ends completely over, then roll. Tomatoes wrapped in this way ship well and present an attractive appearance, as there are no chinks in the basket. It takes a little longer than wrapping as oranges are put up.

Five and eight-pound baskets were ordered. The so-called five-pound baskets held an average of 3 pounds each. The eight-pound baskets held an average of 6 pounds, 6 ounces of tomatoes, and sold for 6 pounds. No difference in price per pound was received in the different baskets. The 6 ounces more of tomatoes in each of the six-pound baskets were worth 11 cents, so that there was a loss in the use of these baskets. If baskets had been secured that held an even 6 pounds of tomatoes, they would doubtless be as good as the three-pound basket.

Best size of tomatoes.—Tomatoes were divided into three different grades according to size. This made the packages appear much more attractive than if put up with all sizes in one basket. It is probable that the smaller size would not otherwise have sold as well, for they looked very small when put with large tomatoes. On ten dates, tomatoes of all three grades were shipped so as to obtain a comparison of their values. In these shipments the average weight per fruit and the number per basket were recorded.

	Average weight per fruit.	Average price per pound.
Largest size	5.8 oz.	$34\frac{1}{2}$ cts.
Medium "	3.3 "	34 "
Small "	2.8 "	30 "

Another point that must be considered is that a basket of the larger size of tomatoes contained a greater weight of tomatoes. The prices received per actual pound of fruit contained in the different grades averaged 30.4, 33.3 and 29.3 cents. The medium size, therefore, gave a little better price although it sold for less per

basket. It is, therefore, desirable that a variety yield fruits that run five to the pound.

At three dates, culls were shipped. These were damaged large tomatoes and those that were too small for any of the regular grades. They were all put together loose in the basket. One would not expect them to have a market value, but they brought an average of 15 cents per pound.

Prices at different times of year.—Table 22 shows the range of prices during the year. Prices were good throughout the winter, but were best in February and March.

TABLE 22.

Range of Prices of Hothouse Tomatoes, 1906.

DATE.	LARGE SIZE.			MEDIUM SIZE.			SMALL SIZE.			CULLS.		
	Baskets.	Pounds.	Price.	Baskets.	Pounds.	Price.	Baskets.	Pounds.	Price.	Baskets.	Pounds.	Price.
			cts.			cts.			cts.			cts.
January 10	2	6	30	4	12	25	3	9	22½	2	6	8⅓
" 15	2	6	30	1	3	30	4	12	25	1	3	16⅔
" 22	2	6	30	3	9	30	4	12	25	1	3	20
" 26	2	6	30	1	3	30	2	6	30	......	......	......
" 31	1	3	35	1	3	35	1	6	23	......	......	......
February 15	......	......	......	1	6	40	1	6	40	......	......	......
March 1	1	6	40	1	6	40	1	6	40	......	......	......
" 6	1	6	40	1	6	40	1	6	40	......	......	......
" 20	1	6	40	1	6	35	......	......	......	......	......	......
" 29	1	6	39	2	12	39	3	18	35	......	......	......
April 4	1	6	35	2	12	35	3	18	32	......	......	......
" 9	1	6	35	2	12	35	½	12	30	......	......	......

The prices received were in most cases the highest market quotations. The average for all fruit shipped, except culls, was 30 cents.

Total income.—A little less than half the crop was shipped to New York, but these shipments were so distributed as to give reliable results on the value of the entire crop.

Nearly all the crop, whether marketed or not, was graded for market. This showed nearly 16 per cent. of the total crop as culls.

The center bench contained 310 square feet and yielded 641.5 pounds; 540 pounds of the first three grades and 101.5 pounds of culls. According to the above prices, they were worth $177, which is equal to 57 cents per square foot of bench space. Notice that this is the gross value. It makes no allowance for overweight in baskets, commission, express, etc.

FUMIGATION FOR THE WHITE FLY (*Aleyrodes*).

The white fly became so bad on the tomato plants in the greenhouse that fumigation had to be resorted to. A number of fumigations with tobacco seemed to have no effect. An all-night fumigation with hydrocyanic acid gas was given, using $\frac{4}{5}$ ounce of potassium cyanide for each 1,000 cubic feet of space. This killed the insects, but caused very great injury to the plants, killing the tips of many of them and injuring leaves on all. Later, an all-night fumigation with less than $\frac{1}{2}$ ounce to 1,000 cubic feet caused some injury. Care was taken to have the house cold, dry and dark. Several different methods of fumigation have been recommended, therefore a series of experiments was started to see what strength we could safely use.

Effect on different varieties.—It is very probable that the differences in results at the different Stations are partly due to the different varieties of plants grown.[1] The variations in tightness of construction of the greenhouse probably caused some of the differences.

Lester's Prolific, Elongated Sparks Earliana and Station Yellow recovered from the first fumigation with almost no injury. Eclipse and Frogmore's Selected had some leaves killed. Stone, Lorillard, Beauty, Perfection and Best of All were much more seriously injured. Most of them had several leaves killed and some had the tips killed.

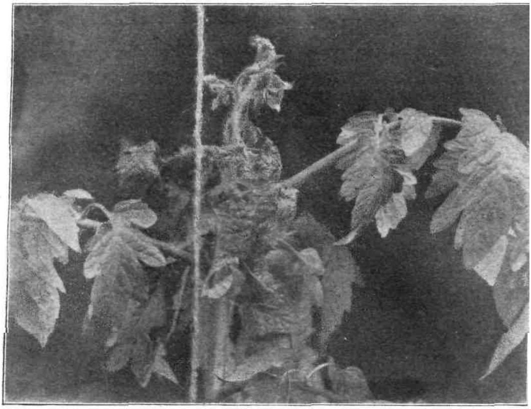


Fig. 4.

Tomato Leaves growing into curled forms as a result of too strong fumigation.

Appearance of injured plants.—Plants that were injured by night fumigation did not show any ill effects until about 4 o'clock the following day. At that time they wilted, as shown on the left and right in Fig. 6.

If not too severely injured, they recovered, but some of the old leaves and the ones that were just starting in the bud grew into much-curled and twisted forms, as shown in Fig. 4. If as severely injured as the one on the right in Fig. 6, the tops usually died.

Details of fumigation experiment.—A number of trials of fumigation were made in a house of 2,070 cubic feet capacity.

Plants in pots were used for the tests. They were about 20 inches tall and averaged about 13 leaves, were rather spindling but were making a rank growth. In each trial some of the varieties most likely to be injured were used and also some least subject to injury. From 8 to 20 plants were used in each trial. The plants were all badly infected with flies. At the end of the time given in each fumigation, the ventilators were thrown wide open.

The potassium cyanide was analysed by Mr. J. P. Street and found to contain 52.08 per cent. K_2O and 40.66 per cent. CN; from which he gives the composition as 70.03 KCN and 22.33 NaCN.

In experiments at some other stations 98 per cent. pure potassium cyanide is said to have been used. This would contain 39.2 per cent. CN. My experiments were, therefore, made with slightly stronger chemicals—40.7 CN.

In all trials the formula used was 1 ounce by weight of potassium cyanide, 2 fluid ounces of sulphuric acid, and 4 of water. One fluid ounce of sulphuric acid was about enough. More was used so as to be sure to have all the potassium cyanide acted upon.

How dangerous is the gas?—Every mention of the use of this gas has dwelt upon the danger to human life. In some cases it has been recommended that the potassium cyanide be suspended from strings over the dishes of acid and that these be lowered by an operator outside the greenhouse. Some later discussions have

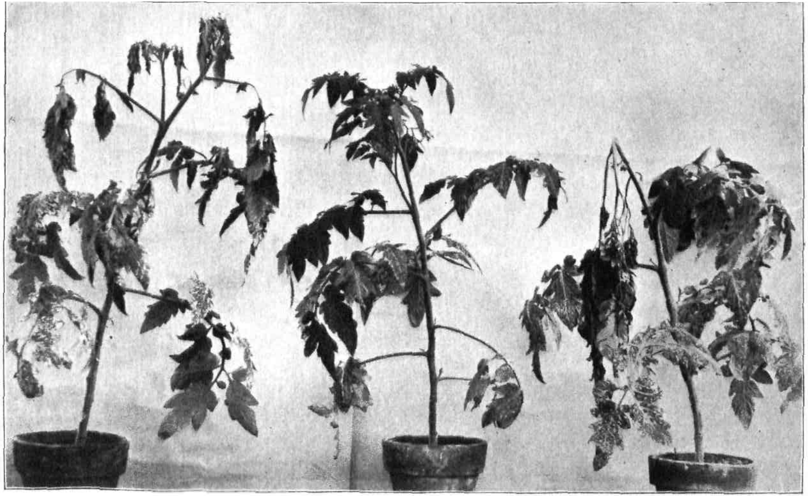
recommended that the potassium cyanide be put in paper bag and dropped into the acid as the operator hurries out of th greenhouse. This practice was followed by the writer.

The exact extent of the danger is a very important questioi when recommending its use to greenhouse men. A number o trials were made by entering the house each time a little soone after ventilation started. Finally, I stayed in the house wher fumigating with 1 ounce of potassium cyanide to 1,000 cubic feet. All these trials were made with Mr. Manning just outside the door to be ready to open it in case of accident. After this I continued to work in the house taking notes during the different fumigations. The effect was to give a slight headache and a little "cold." I have been in chemical laboratories that were worse.

I have hesitated to publish these results for fear that they might lead someone to be careless in the use of this gas. It is a deadly poison, and great care must be observed in its use. But at this very weak strength it was not dangerous to Mr. Manning or myself. It might have been dangerous to some men. It would be unsafe to enter a house where stronger applications are made. The effect might be very serious, if not fatal. If one should inhale the fumes from a dish when they are being given off rapidly it would also be extremely dangerous. In handling the potassium cyanide, it must also be remembered that it is a poison when swallowed.

With proper cautions this gas can be safely recommended to greenhouse men. The chief difficulty has been the question of ventilating after the fumigation has continued the proper time. I think that it will be safe for a man to take a full breath and step into a house and open the ventilators, breathing as little as possible in the house. In this case there should always be a second man at the door. In fact, there should always be two men present when fumigating.

Effect on other kinds of plants.—The all-night fumigation with $\frac{4}{5}$ ounce of potassium cyanide which seriously injured tomatoes, did not hurt beans, lettuce, cucumbers or any of a large number of "house" plants, except chrysanthemums.



15 minutes, daylight. | 35 minutes, dark. | 30 minutes, daylight.

Fig. 6.

)uring the series of 14 trials there were in the house: palms several kinds, asparagus, geraniums, smilax, ferns, coleus, tus, orange, rubber plant and lilies. None of these were ıred except asparagus and coleus.

?esults of experiments.—Table 23 gives a summary of the eximents, also of the regular fumigations of the tomato house ch contained 7,400 cubic feet.

n each trial the flies at a distance of 10 feet from the jars be- to drop in 2 to 3 minutes. They would apparently all be d at the end of 5 minutes, but would revive if removed at t time.

fumigation of 15 to 20 minutes seems to be enough.

few fairly satisfactory daylight fumigations were made, but way was found that could be depended upon to kill the flies not injure the plants.

To all-night fumigation was made that killed the flies without ous injury to some plants.

'umigation for about 15 minutes with 1 ounce of potassium nide per 1,000 cubic feet when entirely dark, was satisfactory.

t seems that any factors that make the plant active increase liability of injury—heat, moisture, light. It is better to have house dry and cool when fumigating, and it should be dark.

amount of wind and openness of the house have a strong uence, when long-time fumigations are given.

Iow to fumigate.—Measure the house and compute its contents cubic feet. For each 1,000 cubic feet use:

1 ounce potassium cyanide,
2 fluid ounces sulphuric acid,
4 " " water.

n a large house several dishes should be used, one for every 00 to 4,000 cubic feet.

'ut the water in the dish, then slowly add the sulphuric acid. glass dish is used, the water must be stirred when the acid is ed so that the heat will not break it. Weigh out the potasn cyanide for each dish and put it in a paper bag. In hand- potassium cyanide, do not forget that it is a strong poison, if llowed. Put the dishes in the house in such positions that

the fumes will not rise directly through tender foliage. Afte is entirely dark, close the ventilators and fasten all the doors l one. When all is ready, begin at the far end of the house a drop the bags of potassium cyanide into the dishes and rapic leave the house.

At the end of 15 minutes, open the ventilators. If there i way to open them without entering the house, it should be us *If this cannot be done, it will probably be possible to step in a* open one without breathing. It will probably be safe to breatl but the first time this should be done with great caution, a there should certainly be another man present.

It would be safer for tomatoes, the first time, to use only $\frac{3}{4}$ oun of potassium cyanide per 1,000 cubic feet and repeat with ounce if it does not kill the flies. Sodium cyanide is often co tained in potassium cyanide, and an ounce of this produces larger amount of gas. If the house is very open it may necessary to use over 1 ounce, but this should not be done t the smaller amount has failed. Fumigation will probably ne to be repeated every three to four weeks.

TABLE 23.

Fumigation Trials.

HOUR.	Sight.	Time.	Ounces per 1,000 cu. ft.	Effect on flies.	Effect on plants.	Results.
2:18 P. M.	Sunshine	60 minutes	1	Killed	Badly injured	Unsatisfactory.
3:48 "	"	15 "	1	"	Badly injured	"
4:26 "	"	15 "	¾	Mostly killed	Not hurt	Fairly satisfactory.
5:01 "	"	15 "	½	¾ killed	Not hurt	Unsatisfactory.
6:00 "	Dark	35 "	1	Killed	Not hurt	Good.
6:30 A. M.	Sunshine	30 "	1	"	Badly injured	Unsatisfactory.
9:45 "	"	20 "	¾	"	Badly injured	"
10:28 "	"	20 "	½	Mostly killed	Slight injury.*	"
6:15 "	Sunrise cloudy	20 "	1	Mostly killed	Slight injury	"
10:00 "	Sunshine	15 "	¾	Mostly killed	Not hurt	Fairly satisfactory.
11:39 "	"	15 "	½	Mostly killed	Not hurt	Fairly satisfactory.
1:30 P. M.	"	20 "	1	Killed	Serious injury	Unsatisfactory.
7:09 "	Dark	20 "	1	Mostly killed	Not hurt	Fairly satisfactory.
7:40 "	"	35 "	1	Killed	Not hurt	Good.

Fumigation of Regular Tomato-House.

HOUR.	Sight.	Time.	Ounces per 1,000 cu. ft.	Effect on flies.	Effect on plants.	Results.
Oct. 16	Moonlight	All night	$\frac{4}{5}$	Killed	Serious injury	Unsatisfactory.
Nov. 25	Dark	" "	$\frac{11}{25}$	Few killed.	Not hurt	"
Jan. 2	"	" "	½	Killed	Slight injury	Fairly satisfactory.
Feb. 17	"	" "	$\frac{2}{5}$	Few killed.	Not hurt	Unsatisfactory.
Mar. 27	Twilight	30 minutes	¾	Mostly killed	Serious injury	"
June 7	Dark	20 "	¾	Mostly killed	Not hurt	Fairly satisfactory.
" 15	"	15 "	1	Killed	Not hurt	Good.
Sept. 16	Starlight	15 "	1	Killed	Slight injury	Fairly satisfactory.

* By slight injury is indicated a degree of damage less than that shown in Fig. 4.

BEAN VARIETY TEST FOR FORCING.

September 29th, beans were planted as a secondary crop along the edge of a bed of tomatoes. One small bed was also planted. They were picked December 4th to 19th, mostly December 11th. The yields, not including culls, are shown in Table 24. Some of the varieties were repeated and some were planted in later crops, but the conclusions were not changed.

The most satisfactory varieties were Currie's Rust-proof Wax, Improved Yellow Eye, Wardwell Kidney, Detroit Wax and Golden Jersey. These are all much alike. All are rich yellow have straight, stringless pods. The Improved Yellow Eye seems to be as good as any variety.

TABLE 24.

Yields of Beans.

VARIETY.	FIRSTS.		SECONDS.		Average weight per pod, ounces.	Relative total yield.*
	Number of pods.	Ounces.	Number of pods.	Ounces.		
Side Bed—10 plants each—						
Curries Rust-Proof Wax	18	5	7	2	0.28	59
Improved Yellow Eye (check)	35	9	17	3	0.23	100
Detroit Wax	18	6	16	4	0.26	81
Refugee Wax	18	3	32	4	0.18	55
Improved Yellow Eye (check)	39	10	15	3	0.28	100
Stringless Green Pod	12	4	15	2	0.22	51
Wardwell Kidney	28	8	14	2	0.24	98
Improved Yellow Eye (check)	32	8	8	1	0.22	100
Solid Bed—7 plants each—						
Davis White Wax	8	2	5	1	0.23	60
Improved Yellow Eye (check)	11	3	10	2	2 24	100
Dwarf Kidney	10	3	6	1	0.25	80
Golden Jersey	5	2	15	2	0.20	80
Improved Yellow Eye (check)	11	3	15	2	0.19	100
Curries Rust-Proof Wax	14	4	15	2	0.21	120
Early Red Valentine	15	4	13	2	0.21	120

*Comparison with the check variety considered as 100 per cent. The change between two

VARIETIES OF RADISHES FOR FORCING.

Three crops of radishes were grown in the greenhouse. The st two crops were sown between sweet peas; the third crop cupied 32 rows, 7 feet long and 4 inches apart. The crops ere pulled as they were needed for use, which was not always the best time, so that the statement of the exact yields would unfair.

Miss Voorhees made notes on the varieties, and considered the llowing as among the best:

Early Round Dark Red	Henderson.
Deep Blood Red Turnip	Thorburn.
Early Scarlet Turnip	"
Early Deep Scarlet Turnip	"
Scarlet Gem	"
Scarlet Globe Shaped	"
French Breakfast Forcing	"
Non Plus Ultra	"
Olive Shaped White Forcing	"

IE USE OF ETHER IN FORCING ASPARAGUS, RHUBARB AND STRAWBERRIES.

The successful use of ether in the forcing of lilacs in France ggested the possibility of its value in forcing the above crops.

Etherizing chamber.—A box 30 x 34 x 60 inches was made of oring boards (matched lumber) and was coated with two layers paper inside. The door was put on with thumb-screws and d a piece of rubber tubing to press against it so that it fitted osely all around. This held the gas quite well. The box was aced in the lettuce-house where the temperature ranged from out 45° to 65°.

Asparagus.—The rows dug for forcing were the plots whose evious records have been reported (Annual Reports 1896–1905). e names and plot numbers in Table 25 refer to these records. ch plot contained 15 roots. The roots were spread so much at they broke in many pieces when dug out. The first two ots given in Table 25 were divided into two equal lots. The her plots were divided into three equal lots. One part was unherized, one was treated with 10 cc. (about ⅓ ounce) per cubic ot of space in the box for 24 hours, one part was similarly

TABLE 25.

Yield of Etherized and Unetherized Asparagus.

VARIETY AND PLOT.	Yield in 1905 in field—oz.	Date started to force.	Yield First Quality.						Total Yield.					
			Unetherized. 10 cc.		Etherized. 10 cc.		Etherized. 15 cc.		Unetherized. 15 cc.		Etherized. 10 cc.		Etherized. 15 cc.	
			No. stalks.	Ounces.	No. stalks.	Ounces.	No. stalks.	Ounces.	No. stalks.	Ounces.	No. stalks.	Ounces.	No. stalks.	Ounces.
Elmira, plot 1	565	Nov. 16	32	12	21	6	.....	.....	101	21	49	10	.....	.....
" " 2	450	" 18	48	16	.....	.....	45	16	151	29	.....	.....	181	32
" " 3	205	Dec. 1	32	9	26	7	18	6	122	23	80	12	88	14
" " 4	287	" 19	18	4	55	16	11	3	76	8	134	23	80	9
Palmetto, plot 1	484	Jan. 11	43	10	65	16	69	14	112	16	139	22	182	24
" " 2	441	" 14	69	20	46	22	31	7	132	26	114	29	111	14
" " 3	428	Feb. 15	59	14	73	19	54	15	120	20	116	23	125	20
Total last five	.....	.....	221	57	265	80	183	45	562	93	583	109	586	81
Average size stalks	.....	.....	.....	0.26	.....	0.30	.....	0.25	.....	0.17	.....	0.19	.....	0.14

The yields of asparagus were all poor. The total yield from each plot averaged less than $\frac{1}{7}$ of the yield produced in the field. The fact that the roots were so much broken in plowing out was doubtless the cause. This difficulty has prevented the forcing of asparagus from developing commercially to any great extent.

The etherization with 10 cc. of ether increased the total yield slightly, but increased the yield of large size stalks very decidedly, from 57 to 80 ounces. The 15 cc. was apparently too strong, as it decreased the yield of good stalks and the total yield.

Rhubarb.—Eighteen uniform, strong roots of rhubarb were dug December 4th. They were divided into three equal lots on December 19th. One lot was untreated, one was etherized with 10 cc. per cubic foot for 24 hours and one was similarly treated with 15 cc. The first two lots were bedded in the lettuce-house December 21st, the third lot was bedded December 23d.

TABLE 26.

Yields of Etherized and Untreated Rhubarb.

DATE OF CUTTING.	YIELD OF GOOD STALKS.						TOTAL YIELD.					
	UNTREATED.		ETHERIZED. 10 CC.		ETHERIZED. 15 CC.		UNTREATED.		ETHERIZED. 10 CC.		ETHERIZED. 15 CC.	
	No. stalks.	Ounces.	No. stalks.	Ounces.	No. stalks.	Ounces.	No. stalks.	Ounces.	No. stalks.	Ounces.	No. stalks.	Ounces.
Feb. 2	18	39	30	69	24	61	18	39	30	69	24	61
" 12	24	68	24	68	26	69	24	68	24	68	26	69
" 21	28	74	31	84	26	76	55	113	31	84	35	89
Mar. 1	8	20	11	35	7	21	42	75	64	116	67	81
" 10	....	....	....	....	3	7	43	66	12	17	25	33
	78	201	96	256	86	234	182	361	161	354	177	333
Average weight per stalk	....	2.6	....	2.7	....	2.7	....	2.0	....	2.2	....	1.9

The photograph for Fig. 7 was taken on January 26th. The roots that were etherized gave a considerably larger yield of good stalks, but gave a little less yield than the untreated. It will

be seen that the increased yield mostly occurred in the first cutting.

It seems that the effect of ether is to cause the plants to throw much more of their energy into the first growth, thus giving a larger yield of good stalks; whether this can be made of use commercially in forcing rhubarb is yet to be determined.

Strawberries.—The trial on strawberries was unsuccessful. The etherized plants blossomed before the leaves had made much growth. The blossoms were mostly on stems that were less than an inch long. It is possible that some other factor influenced the result.

PRESERVATION OF GREENHOUSE BENCHES.

The conditions in a greenhouse are extremely favorable for the decay of lumber. New benches were put in the tomato-house in the fall of 1905. The sides of the benches are white pine and the bottoms hemlock. Sixteen beds were treated in different ways to compare different preservatives. Tar, creosote, S. P. F. Carbolineum, whitewash, cement, copper sulphate, copper sulphate followed by cement, and copper sulphate followed by whitewash, were each tried.

When the dirt was removed in the summer of 1906, the benches that were not treated were decayed from one-fourth to one-half of the way through the boards.

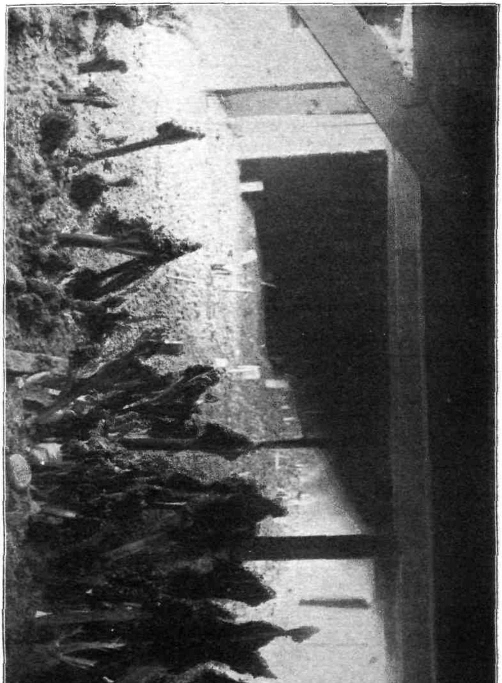
All the treated beds were in better shape, but those treated with cement, lime, tar and creosote were showing considerable decay.

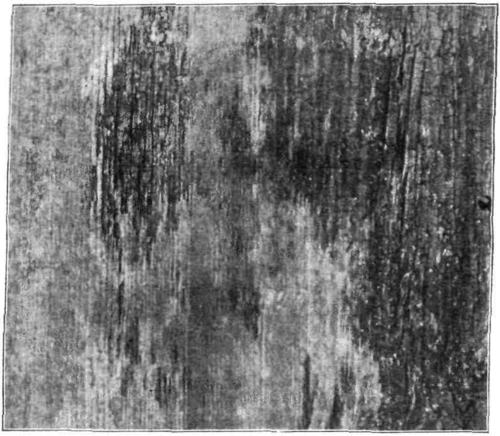
The bed treated with copper sulphate alone was in better shape, but not as good as those where this was followed by lime or cement.

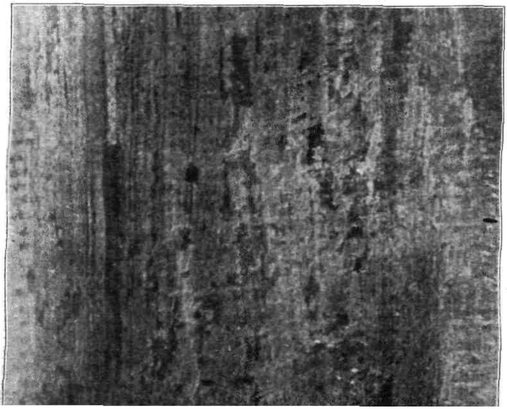
The beds treated with copper sulphate and whitewash or cement, and the one treated with S. P. F. Carbolineum were in decidedly the best shape. They showed no decay, except a single board in one bed treated with copper sulphate.

It is too soon to draw a comparison between these two methods, but not too soon to be sure that either one is far superior to any of the other substances tried.

The copper sulphate was dissolved in water, 2 pounds per







llon. This strong solution was applied with a spray pump. l was applied that would stay on the wood. From one to ır applications were made on different beds, which required m 2 to 5 pounds of copper sulphate per 100 square feet of ard surface. Where more than one spraying was given, time s allowed for the spray to dry in between applications.

Lime was made into a whitewash and applied with a brush lowing the last application of copper sulphate. When cement s used in place of whitewash, 10 pounds of Portland cement re mixed with about 2 quarts of water and applied with a ısh.

The idea in applying in this manner is that copper sulphate is good germicide and fungicide, but that it is so soluble that it ght leave the wood. Whitewash (CaOH) is also soluble l soaks into wood. It seems possible to get the copper phate to soak into the wood, then follow it with white-sh and so have the less soluble copper hydrate and cal-m sulphate formed. If mixed before applying, Bordeaux xture would be formed. This is so insoluble that it does not dily enter wood. The idea is to form this insoluble Bordeaux xture in the wood. How well this theory is carried out was determined except by appearances, and by the preserving ct which the treatment had.

The S. P. F. Carbolineum was applied with a brush at the e of one gallon to 160 square feet. It is sold by Bruno sche & Co., 27 William street, New York City, at 80 cents gallon in 20-gallon kegs. The above applications, therefore, 50 cents per 100 square feet.

Two sprayings with copper sulphate required an average of ut 3 pounds per 100 square feet. This is worth 18 cents; lime for the whitewash is worth about 6 cents. The total of this treatment is, therefore, about half as much as the bolineum. With the methods which I used in applying this tment it took 22 minutes per 100 square feet, and the Car-neum 30 minutes.

s previously stated these two treatments are both preserving beds at present, so that their relative value will have to be ermined in the future. Either one is a profitable investment.

THE YIELDS IN THE ORCHARDS.

The arrangement of the orchard is the same for the differe fruits. Each plot contains two trees of each row; each row is different variety. The plots are separated by a crosswise row odd varieties (called Variety trees in the tables), to prevent inte feeding. *These varieties may, therefore, be compared with eac other*, where they separate the same fertilizers. This is indicate on the tables. Table No. 27 shows the scheme of fertilizers f the entire orchard. Tables Nos. 28 to 32 show the yields of th various fruits for this year.

TABLE 27.

Showing Fertilizer, Amounts and Time of Application for th Various Fruit Trees.

KIND OF FRUIT.	Plot 1.	Plot 2.	Plot 3.	Plot 4.
Apples	Nothing	500 lbs.‖ B., P. & A. P.† applied in spring.	500 lbs. B., P. & A. P. applied in spring.	
Peaches	Nothing	500 lbs. B., P. & A. P. applied in spring.	500 lbs. B., P. & A. P. applied in spring; 150 lbs. nitrate soda applied early and turned under.	500 lbs. P. & P.‡ applied spring; 150 l nitrate soda a plied early a turned under.
Standard Pears	Nothing	500 lbs. B., P. & A. P. applied in spring.	500 lbs. B., P. & A. P. applied in spring; 150 lbs. nitrate soda applied early and turned under.	
	Plots 1 and 4.*	Plots 2 and 5.	Plots 3 and 6.	
Dwarf Pears	Nothing	500 lbs. B., P. & A. P. applied in spring.	500 lbs. B., P. & A. P. applied in spring; 150 lbs. nitrate soda applied early and turned under.	
	Plots 1 and 3.*	Plots 2 and 4.		
Plums, Cherries	500 lbs. B., P. & A. P. applied in spring.	500 lbs. B., P. & A. P. applied in spring; 150 lbs. nitrate soda applied early and turned under.		

‖ The quantities of fertilizers given are in all cases the amount per acre to be applied.

† An even mixture of ground bone, muriate of potash and acid phosphate.

‡ A mixture of muriate of potash and acid phosphate in the proportion of 1 lb. of the former 2 lbs. of the latter.

* Plots 1, 2 and 3, Dwarf Pears, and 1 and 2, Plums and Cherries, are irrigated as occasi demands.

TABLE 28.

Plums—Yields 1906.

VARIETIES IN PLOTS.	Date marketable.	IRRIGATED.				UNIRRIGATED.			
		PLOT I.		PLOT II.		PLOT III.		PLOT IV.	
		Tree 1.	Tree 2.	Tree 1.	Tree 2.	Tree 1.	Tree 2.	Tree 1.	Tree 2.
		lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.
Lombard	Aug. 29–Sept. 18.	168—12	170—10	110—13	144—2	82—6	60—11	21—6	1—8
Newman..........	July 27–Oct. 1...	113—5	82—10	62—10	207—0	144—6	106—2	159—6	77—15
Shropshire Damson.........	Aug. 30...	....	....	....	46—14	60—4	....	....	....
Grand Duke........	Sept. 8-19...	46—2	....	....	55—8	29—14	87—3	58—2	65—2

† VARIETY TREES.	Date marketable.	Tree 1.	Tree 2.	Average yield per tree to date. *Set in 1896.*	No. of years bearing.
		lbs. oz.	lbs. oz.	lbs. oz.	
Imperial Gage............................	Aug. 30–Sept. 4..	53—6	69—2	18—8	5
Victoria..	*Aug. 24*...	*43—4*	*57—2*	*20—7*	*5*
Burbank..	Aug. 6...	45—2	231—6	46—9	8
Abundance......................................	Aug. 7...	56—12	14—12	26—8	7
Bavay's Green Gage*......................	Sept. 5-13...	108—6	63—2	21—4	8
Washington....................................	Sept. 6...	8—6	11—2	3—9	3
French Damson...........................	*Aug. 29*...	*3—5*	*14—15*	*11—11*	*7*
Satsuma Blood................................	....	....	....	14—1	6

† *All these trees receive the same fertilizer treatment.*

* Those above star are in irrigated section, though no water has been applied since 1902.

TABLE 29.

Cherries—1906.

VARIETIES IN PLOTS.	Date marketable.	IRRIGATED.				UNIRRIGATED.			
		PLOT I.		PLOT II.		PLOT III.		PLOT IV.	
		Tree 1.	* Tree 2.	Tree 1.	Tree 2.	Tree 1.	Tree 2.	Tree 1.	Tree 2.
		lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.
Large Montmorency	June 23-26	4— 4	32—12	7— 6	7—13	10— 4	2— 9	2—13	13—13
Louis Phillippi	June 21-26	77— 2	40— 4	54— 4	55—12	57— 8	9— 2	58— 8	108— 8
Early Richmond	June 16-22	66—11	95— 4	94— 3	179—15	82— 6	147—10	98— 8	149— 4

† VARIETY TREES.	Date marketable.	Tree 1.	Tree 2.	Average yield per tree to date. Set in 1896.	No. of years bearing.
		lbs. oz.	lbs. oz.	lbs. oz.	
Osthein	June 21-24	29—14	49— 0	11— 2	8
Royal Duke	June 22	58— 9	56— 2	16—10	7
Reine Hortense	June 30-July 3	12— 0	2— 0	3— 0	8
English Morello*	July 5-11	81— 7	67— 9	35— 2	8
Montmorency Ordinaire	June 30-July 3	151— 8	117— 9	46— 6	8
May Duke	June 21	60— 8	21— 0	13— 3	8

† All trees receive same fertilizer.

* Those above star are in irrigated section, though no water has been applied since 1902.

TABLE 30.

Apples.

VARIETIES IN PLOTS.	Date marketable.	Plot I.				Plot II.				Plot III.			
		Tree 1.		Tree 2.		Tree 1.		Tree 2.		Tree 1.		Tree 2.	
		Number of fruits.	Weight.	Number of fruits.	Weight.	Number of fruits.	Weight.	Number of fruits.	Weight.	Number of fruits.	Weight.	Number of fruits.	Weight.
			lbs. oz.		lbs. oz.		lbs. oz.		lbs. oz.		lbs. oz.		lbs. oz.
Smith's Cider	Oct. 20	....	....	8	1— 6	75	17— 6	9	2— 0	89	26—12	18	5— 2
Baldwin	Oct. 20	....	....	88	29—10	1	0— 8	22	7— 6	27	11—10	21	8— 4
King Tompkins	Sept. 26–Oct. 1	3	2— 0	45	15— 7	23	8—15	26	7— 1	6	2—14	84	17— 8
Jonathan	Sept. 26	....	....	21	7—10	93	32—10	80	34— 6	94	22—11	4	1— 3
Oldenberg	Aug. 27	25	5—11	109	19— 4	225	46— 0	394	70—13	204	45— 2	234	47— 8
Gravenstein	....	....	....	....	....	....	....	....	....	....	....	....	....

TABLE 30—Continued.

Apples.

VARIETY TREES.	Date marketable.	Plot 1. Tree 1. Number of fruits.	Plot 1. Tree 1. Weight.	Plot 1. Tree 2. Number of fruits.	Plot 1. Tree 2. Weight.	
			lbs. oz.		lbs. oz.	
Stump	....	....	....	....	....	
Yellow Transparent	July 16	191	36— 1	66	13— 0	Alike in fertilizer treatmen
Williams' Favorite	Aug. 6	1	0— 5	8	1— 2	
Ben Davis	Oct. 20	406	99— 4	257	74—14	
Monmouth Pippin	Oct. 10	50	18— 2	92	32— 2	Alike in fertilizer treatmen
Barry	Sept. 7	137	42— 0	104	31— 2	

TABLE 31.

Standard Pears.

VARIETIES IN PLOTS.	Date marketable.	Plot I.				Plot II.				Plot III.			
		Tree 1.		Tree 2.		Tree 1.		Tree 2.		Tree 1.		Tree 2.	
		Number of fruits.	Weight.	Number of fruits.	Weight.	Number of fruits.	Weight.	Number of fruits.	Weight.	Number of fruits.	Weight.	Number of fruits.	Weight.
			lbs. oz.		lbs. oz.		lbs. oz.		lbs. oz.		lbs. oz.		lbs. oz.
awrence	Oct. 28	1,134	174— 0	416	52— 8	785	169— 2	387	80—14	807	98— 6	750	183—14
artlett	Sept. 17	183	39— 7	324	73—12	81	26— 6	...	...	147	35—13	212	66— 6
ieffer	Oct. 30	949	185— 1	1,192	151— 8	943	381—10	1,753	316— 0	714	217—12	1,360	273— 6
lapp's Favorite	Aug. 27	...	...	...	...	...	...	3	1— 6	...	...	...	...
heldon	Oct. 12	54	17— 0	...	...	...	...	338	36—10	49	15—10	28	10— 9
eckel	Oct. 8	254	30—11	820	81— 4	17	3— 6	478	55—14	291	36— 0	...	...

TABLE 31—Continued.

Standard Pears.

VARIETY TREES.	Date marketable.	PLOT 1. TREE 1. Number of fruits.	PLOT 1. TREE 1. Weight.	PLOT 1. TREE 2. Number of fruits.	PLOT 1. TREE 2. Weight.	
			lbs. oz.		lbs. oz.	
Angel	Sept. 9	13	4—12	116	31— 4	
Flemish Beauty	Sept. 30	373	135— 2	....	....	Alike in fertilizer treatme
Giffard	July 25	732	83—14	....	....	
Dorsett	Oct. 30	770	136—14	1,056	189—15	

TABLE 32.

Dwarf Pears.

VARIETIES IN PLOTS.	Date marketable.	Irrigated.											
		Plot I.				Plot II.				Plot III.			
		Tree 1.		Tree 2.		Tree 1.		Tree 2.		Tree 1.		Tree 2.	
		Number of fruits.	Weight.	Number of fruits.	Weight.	Number of fruits.	Weight.	Number of fruits.	Weight.	Number of fruits.	Weight.	Number of fruits.	Weight.
Dwarfs.			lbs. oz.		lbs. oz.		lbs. oz.		lbs. oz.		lbs. oz.		lbs. oz.
Lawrence	Oct. 30	189	26—14	191	27— 6	....	....	111	16— 1	271	31— 8	267	36— 8
Bartlett	Sept. 7	4	1—15	32	11— 1	....	....	96	24—14	172	55—11	277	66— 8
Dwarfs by Cutting.													
Lawrence	....	291	56—10	417	66— 6	57	12—14	....	....	....	....	577	72— 9
Bartlett	....	110	19— 4	229	84— 3	179	48— 6	61	15— 8	52	14— 6	38	14— 8
Keiffer	Oct. 27	929	129— 8	946	218— 8	1,550	378— 8	733	218— 9	1,076	349— 2	1,176	326— 6

TABLE 32—Continued.

Dwarf Pears.

VARIETIES IN PLOTS.	Date marketable.	UNIRRIGATED.											
		PLOT IV.				PLOT V.				PLOT VI.			
		TREE 1.		TREE 2.		TREE 1.		TREE 2.		TREE 1.		TREE 2.	
		Number of fruits.	Weight.	Number of fruits.	Weight.	Number of fruits.	Weight.	Number of fruits.	Weight.	Number of fruits.	Weight.	Number of fruits.	Weight.
			lbs. oz.		lbs. oz.		lbs. oz.		lbs. oz.		lbs. oz.		lbs. oz.
Dwarfs.													
Lawrence	....	246	24— 4	10	1— 6	182	22— 8	144	18— 6	123	18— 2	258	37— 4
Bartlett	....	9	2— 0	11	2— 6	172	41—10	173	30— 6	4	0— 6	3	1— 4
Dwarfs by Cutting.													
Lawrence	....	220	38— 4	266	47— 0	135	21— 2	610	118— 2	746	111— 0	392	51— 8
Bartlett	....	124	30— 6	146	49—12	23	6—14	7	2— 6	192	61— 8	216	39— 8
Keiffer	....	1,129	266— 0	1,128	298— 4	1,201	357—10	999	271— 6	924	276— 2	890	283— 8

TABLE 33.

Dwarf Variety Trees.

VARIETY TREES.	Date marketable.	DWARFS. Tree 1. Date of setting.	Tree 1. Number of fruits.	Tree 1. Weight.	Tree 2. Date of setting.	Tree 2. Number of fruits.	Tree 2. Weight.
				lbs. oz.			lbs. oz.
{*Margaret	Sept. 24	1896	141	13—11	1896	196	16—12
{ Angouleme	Oct. 10	1896	63	18—14	1896	48	15— 8
{ Clapp's Favorite	Aug. 30	1896	200	41—10	1896	14	2—14
{ White Doyenne	Sept. 24	1896	268	35— 1	1896	575	75— 9
{ Howell	Sept. 25	1896	227	39— 9	1896	296	55—11
{ Seckel	Oct. 18	.....	.....	.....	1896	304	23— 0

VARIETY.	Date marketable.	DWARFS BY PRUNING. Tree 1. Date of setting.	Tree 1. Number of fruits.	Tree 1. Weight.	Tree 2. Date of setting.	Tree 2. Number of fruits.	Tree 2. Weight.
				lbs. oz.			lbs. oz.
{*Anjou	.....	1897	.....	.....	1902	.....	.....
{ Clapp's Favorite	Aug. 27	1897	193	34—14	1896	173	43—12
{ Lucrative	Sept. 24	1902	43	7—11	1896	.....	.....
{ Margaret	Sept. 24	1896	289	24—10	1902	.....	.....
{ Le Conte	Oct. 2	1896	1,205	212—14	1896	570	156— 1
{ Seckel	Oct. 8	1901	.....	.....	1896	274	29— 0
{ Clarigeau	Oct. 8	1901	23	10— 8	1896	27	8—17
{ Sheldon	Oct. 8	1896	57	20— 0	1896	33	11—14
Howell	Sept. 25	1896	241	44—14	1896	71	19— 1

* Trees in brackets receive same fertilizer treatment.

PRECIPITATION RECORDS.

Records of the daily precipitation have been kept as usual at the College Farm. Although the rainfall has come short of the normal and average amount for this section for three-quarters of the months, the season has not been dry. It was only necessary to irrigate a little in June for the strawberry crop.

TABLE 34.

Monthly Precipitation, in Inches, Since January, 1896.

YEAR.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	*Yearly total.*
1896..........	....	....	*1.68*	*5.85*	*5.92*	*1.41*	*3.70*	*4.93*	*4.37*	*2.42*	*4.81*	*1.62*	*36.71*
1897..........	2.95	1.59	2.39	2.77	2.47	3.47	6.45	2.50	12.84	3.81	2.10	1.59	44.93
1898..........	4.52	5.09	3.92	3.49	3.09	4.17	7.86	1.13	3.91	6.44	1.46	5.80	50.88
1899..........	7.14	3.16	4.88	5.37	6.63	1.50	2.04	3.54	6.32	3.45	7.80	2.96	54.79
1900..........	*4.11*	*2.06*	*4.35*	*5.30*	*3.40*	*2.38*	*5.58*	*2.64*	*6.94*	*2.24*	*3.30*	*3.53*	*45.83*
1901..........	4.27	2.32	2.01	0.76	5.19	7.39	5.01	0.81	9.12	8.90	1.86	1.99	49.63
1902..........	2.21	7.30	2.70	6.46	3.79	3.09	1.51	6.08	3.42	6.29	5.25	7.76	55.86
1903..........	1.58	6.83	3.84	4.61	4.74	4.57	0.29	7.35	5.07	5.97	3.69	7.16	55.70
1904..........	*1.21*	*3.53*	*3.11*	*2.52*	*2.38*	*3.49*	*2.79*	*2.50*	*7.99*	*13.01*	*5.09*	*5.80*	*53.42*
1905..........	2.70	2.07	2.67	2.14	4.02	2.83	1.83	1.83	4.23	4.96	4.32	2.99	36.59
1906..........	2.01	3.39	3.04	2.04	4.28	4.38	4.75	3.20	6.10	3.95	1.93	3.02	42.09
Average......	3.27	3.73	3.14	3.75	4.17	3.51	3.81	3.32	6.39	5.58	3.78	4.02	48.47
Normal for section......	3.74	3.66	3.82	3.64	3.77	3.68	4.02	3.80	4.92	4.93	3.94	3.45	47.37

TABLE 35.

.ily and Monthly Precipitation, in Inches, at the College Farm, for the Year Ending October 31st, 1906.

DATE.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.
									0.48			
							0.03	0.26		1.76		0.04
		0.57	0.14		1.32		0.08	T	0.06	0.60	0.27	
	T		1.57		1.14				1.40	0.13		
												1.00
	0.16					0.04	0.07	T				T
						0.08	0.39	0.04				T
			0.05						0.30	T		
			0.07	0.82		0.04	0.32		0.24	0.19		0.26
		0.34			0.14	0.72		0.14	0.03			0.12
						1.29		0.11		0.23		
			0.16			0.25						
					T							
			0.46	T			0.08				0.14	
			0.06	0.17	0.59							
		0.04	0.17			1.19		0.15				
	0.08							0.28	1.30			
			0.06	T			0.30	0.79	0.15			T
					0.64			0.44				0.04
					0.05						0.18	0.31
		1.55		0.18					1.07	0.55	T	0.77
				0.43				0.15	0.60		1.02	T
		0.15				0.70		0.03	0.14			0.12
			0.20			0.03		0.04				
	T			0.44								0.11
				T	0.04					T		
	T				0.12		0.82			0.39	0.32	
	0.27		0.11				1.68					
	1.30	0.74					0.98	0.69	0.33	0.10		
	0.20				0.05	0.04		0.08				
					0.19							0.25
otal	2.01	3.39	3.04	2.04	4.28	4.38	4.75	3.20	6.10	3.95	1.93	3.02
ormal	3.74	3.66	3.82	3.64	3.77	3.68	4.02	3.80	4.92	4.93	3.94	3.45

REPORT OF THE DAIRY HUSBANDMAN.

REPORT OF THE DAIRY HUSBANDMAN.

FEEDING EXPERIMENTS.

Three feeding experiments were conducted, the details of which will be published in a separate bulletin.

I. Home-grown Protein vs. Purchased Protein.

This experiment is a continuation of a line of investigation started several years ago to ascertain to what extent leguminous crops such as alfalfa, crimson clover and cow peas can be grown to reduce the necessity of purchasing concentrated feeds.

Since all previous experiments have been made with short feeding periods, the object of the present test was to learn whether a ration furnishing all the protein from home-grown crops could be fed continuously and be practical in respect to maintaining the yield of milk and health of the animal as well as being economical. The experiment covers a period of four months. Thirty-one pounds of silage and all the alfalfa hay they could eat was compared with 40 pounds of silage, 7 pounds of corn stalks, and 10½ pounds of a good feed ration.

There was a decrease of about 17 per cent. of milk from the alfalfa ration. This was probably due to the large amount of crude fiber, about one-fourth, in the alfalfa hay. While the animals did not lose flesh more rapidly than when given the feed ration, their general appearance was not as good. The conclusion to be drawn is that it is not advisable to furnish all of the protein of a ration of alfalfa hay, but to supplement with a small amount of concentrated feed.

II. Gluten Feed vs. Dried Corn Distillers' Grains.

This experiment was largely a repetition of that made a year ago, but comparing the distillers' grains, however, with gluten feed instead of dried brewers' grains and cottonseed meal. There

is an increasing amount of this class of concentrates in the market, and being quite bulky in character, can be fed with more solid feeds, eliminating the necessity of wheat bran for bulk. The experiment covers two periods of 30 days each. There was very little difference between the two rations, the distillers' grains being fully as economical.

III. Corn Silage vs. Soiling Crops for Summer Feeding.

This experiment was necessarily a preliminary one, as there was not silage enough to give the definite results of a longer feeding period. A herd of 21 cows was fed for 3 weeks on a ration entirely of corn silage with 7½ pounds of concentrated feeds. This ration was compared with a soiling ration of wheat fodder and 7½ pounds of feed. The soiling ration was fed in the first period and the silage ration in Period II. There was a little shrinkage of milk in the silage period; about 3 per cent., which is below the average monthly shrinkage according to 10 years' records from soiling crop rations at this time of year. At least the experiment showed that the herd produced as satisfactory results on the silage ration. This experiment will be continued.

FORAGE CROP EXPERIMENTS.

I. Soiling Crops, 1906.

The season has been favorable to the growing of soiling crops, notwithstanding a considerable rainfall which sometimes prevented cultivation. Only on low, strongly clay soils, not well drained did the crops suffer from excess of rain. On one field of this character, planted to corn, the yield of forage was good, but the yield of large mature ears was poor. No serious showers occurred to damage growing crops with one exception, namely, a windstorm in July which laid low a field of late planted corn. The storm, however, had no serious effect on earlier planted fields where the stalk was more mature. Rye and wheat passed the winter well and produced good yields of forage. Crimson clover, which winter-killed the two previous years, maintained a good stand and the yield when harvested was fully up to the average.

lfalfa responded to the moist conditions, giving three cuttings, ı increase in yield over last year. A lack of rain in August ıterfered with the growth of the fourth crop. This matured so te that it seemed advisable to allow it to remain as a protection ır winter. The millet crop which was almost a failure last ·ason made a remarkable growth. Peas and oats were fully up ı the average in yield and quality with a marked development ' pea vine. Very early-planted cow peas were almost a failure. hey germinated poorly and what grew were choked with ımmer grass, but the later plantings in June and July, even July 8th, made a remarkably good growth and yield. The wet eather prevented thorough cultivation on our soils, and on some ·lds planted to corn the summer grass could not be checked. his did not seriously interfere, however, with the growth of the ·op.

The soiling system of feeding was continued as in previous ·ars, except in June when the herd was fed silage left over from inter. This was fed as a preliminary experiment with green rage and has been reported in a bulletin. A two-acre exercise ırd was converted into a tillage field and a smaller yard was ılarged to take its place. This yard contains but an acre and quired some feeding of green forage in the stable, but in dry eather the usual system of scattering the roughage in the yard as continued. During hot weather the cows were turned out ımediately after milking.

Table I. gives the forage rotation furnishing green feed to 35 lult and 12 young animals 142 days. The table includes the .age period in order to give a continuous record of feeding. The rage which was planted in the rotation at this time, namely, ·as and oats, was made into hay. The small yield of grass may · explained by the fact that it was cut from lawns having but .tle attention or plant food. Table II. gives the cost of seed, anure and fertilizer and labor for each crop. It also includes .e total food nutrients. Seed and fertilizers were charged at .rrent prices, barnyard manure at $1.50 per ton and where two ops were grown in a season, one-half of the manure was charged each crop. Man and team were charged at 30 cents per hour.

This was fair since a liberal estimate of time was recorded. A careful estimate of team work in cutting and hauling green crops to the barn justifies us in making a charge to the crops of 50 cents per ton for this labor.

The total nutrients in 225½ tons of green fodders is equivalent to that in 48 tons of red clover hay. If the total carbohydrates and fat of the soiling crops is compared with that of corn silage, 191 tons of silage would contain the same amount of these nutrients and leave a balance of 6,130 pounds of protein which could be furnished in 14 tons of gluten feed or 20 tons of bran. Alfalfa, cow peas and other legumes, as well as young rye, wheat and pasture grass, furnish a large proportion of protein and from one-fourth to one-half of the feed ration, and from 6 to 8 pounds daily should be corn, hominy meal, dried beet pulp or feeds of that nature.

Acreage, Date of Planting and Cutting, and Yield of Soiling Crops.

Acreage.	Seed used per acre.	KIND.	Date of seeding.	Period of cutting and feeding.	Number of plot.	Number days between seeding and cutting.	Total yield.	Yield per acre.
	bush.		1905.					
5	2	Rye	Oct. 1-12	May 2-May 18	C, D, M, N, O		20.70	4.14
3	2	Wheat	Sept. 27-30	" 19-June 6	A, B, 26		19.43	6.48
1		Grass		June 7- " 8	Lawn		2.60	
		Silage		" 9-July 2				
4⅘		Alfalfa (second cutting)	Aug., '03, '04	July 3- " 15	20, 21, 22, 23, 24		18.70	3.90
2½		Grass		" 16- " 21	Lawns		9.25	
2		Grass		" 22- " 26			7.40	
2	¾	Jap. Barnyard Millet	May 21	" 27-Aug. 3	M & N	51	15.40	7.70
1	⅓	White Flint Corn	" 11	Aug. 4- " 11	H	85	12.40	12.40
¾	¾	Jap. Barnyard Millet	June 25	" 12- " 17	27	48	10.70	14.30
1		Alfalfa		" 18- " 19	19		3.76	3.76
1	1½	Cow Peas	May 22	" 20- " 23	O	90	7.63	7.63
11		Second Crop Grass		" 21-Sept. 4	4 to 15		20.31	1.85
1	$\frac{5}{16}$-1¼	Kaffir Corn and Cow Peas	June 19	Sept. 5- " 12	26	78	12.60	12.60
1	⅜	Field Corn (S. White)	May 15-20	" 13- " 17		88	11.50	11.50

TABLE I—Continued.

Acreage, Date of Planting and Cutting, and Yield of Soiling Crops.

Acreage.	Seed used per acre.	KIND.	Date of seeding.	Period of cutting and feeding.	Number of plot.	Number days between seeding and cutting.	Total yield.	Yield per acre.
	bush.		1905.					
¾	....	Forage Plot Experiment	June 15-19	Sept. 18-Sept. 21	31	....	7.00	9.33
2	1½	Cow Peas	July 16	" 22- " 28	C & D	68	12.60	6.30
1	1⅓ (rows.)	Cow Peas	" 20	" 29-Oct. 2	25	71	7.55	7.55
5	6	Cow Peas	" 28	Oct. 3- " 16	Triangle	67	26.00	5.20
		Total*					225.56	....
		Average yield, excluding grass					....	8.06

*Supplying forage to 35 adult and 12 young animals 142 days.

TABLE II.

Cost and Total Nutrients in Fodders.

KIND.	Tons.	COST.					TOTAL NUTRIENTS.		
		Seed.	Manures and fertilizers.	Labor.	Total.	Average per ton.	Protein.	Fat.	Carbohydrates.
							lbs.	lbs.	lbs.
Rye	20.70	$6.30	$15.00	$19.35	$40.65	$1.96	952,2	228.4	7,907.4
Wheat	19.43	6.60	5.00	41.91	26.51	1.36	931.2	271.6	6,906.4
Grass	19.25	....	16.50	22.00	38.50	2.00	1,347.0	308.0	5,274.0
Alfalfa	22.46	....	11.31	14.00	25.31	* 1.13	2,025.0	405.0	7,830.0
Jap. Barnyard Millet	26.10	5.35	23.01	25.15	53.51	2.05	783.0	312.2	7,621.2
Thor. White Flint Corn.	12.40	.66	9.63	11.45	21.74	1.75	421.6	148.8	4,092.0
Southern White Corn	11.50	.45	10.92	10.58	21.95	1.91	345.0	230.0	5,290.0
Kaffir Corn and Cow Peas	12.60	2.56	10.52	11.40	24.48	1.94	630.0	176.4	3,099.6
Variety Experiment Plot	7.00	1.80	4.47	7.86	14.13	2.02	196.0	70.0	2,114.0
Cow Peas	53.78	19.56	39.65	57.65	116.86	2.16	3,334.4	752.9	13,068.2
Second Crop Grass	20.34	....	16.50	12.00	28.50	1.40	894.9	261.1	5,369.8
Total	225.56	$43.28	$157.51	$206.35	$412.14	$1.82	11,860.3	3,168.4	68,572.6

Average cost per ton of forage, $1.82.

FIELD NOTES.

Rye and Wheat.

Although sowed considerably later in the fall of 1905 than usual for early spring cutting, the first heads of rye appeared May 2d, at which time cutting and feeding began. The yield from five acres averaged only four tons per acre, notwithstanding that three acres were top-dressed with manure in the winter. Either the lateness of the planting or the climatic condition must have had an influence. Wheat made an excellent growth in early May, yielding an average of over six tons per acre with no top-dressing. One acre of wheat was planted after a crop of corn and cow peas with no application of manure or fertilizers, yet

produced a yield of 7.5 tons per acre. The influence of the c peas on the succeeding crop was marked, since two acres of wh *planted on about the same character of soil with as heavy* application of manure and fertilizers the previous season, a in addition, 25 bushels of stone lime per acre in the fall, p duced a yield of only six tons of wheat fodder per acre.

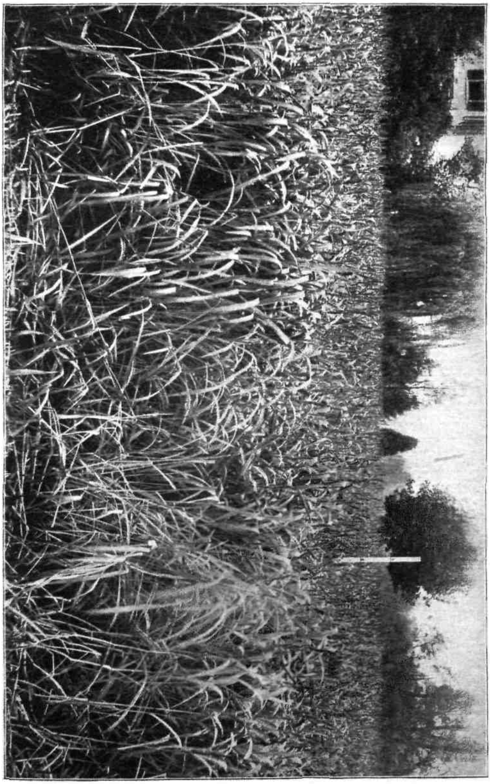
Alfalfa.

While alfalfa has usually come into our soiling rotation sim because we did not have any soiling crops to feed at this parti lar period, namely, after peas and oats and before millet, it l been our object to make as much of the alfalfa into hay as po ble, so as to reduce the necessity of buying concentrated feeds winter. *Alfalfa, therefore, will be more fully discussed un* "Field Crops." Alfalfa is a soiling crop, however, and the fi cutting would come in the rotation from May 25th to June 5th, i mediately after wheat; the second cutting from July 1st to 1(and the third cutting from August 10th to 20th. The first c ting is often at a period of unsettled weather, and, therefore, oft more advantageous to feed green.

Barnyard Millet.

Two acres of barnyard millet was planted on May 24th and acres on June 25th, and while a month elapsed between the t *plantings, there was but two weeks between the period of feedi* Early-planted millet usually makes a much slower growth first, and an application of fertilizer containing a larger per ce of quickly-available nitrogen, in the form of nitrate of soda, w probably return profitable results at this cooler period of t year. The two acres planted first received a very liberal to dressing of manure in November, and 200 pounds per acre of *fertilizer in the drill, maturing a crop 54 days after plantir* yielding 7.7 tons of green forage per acre.

The field planted a month later was grown on alfalfa s which had been down five years. Dandelions and plantain h replaced considerable of the alfalfa, even though disking



August, 1904, seemed to cut out all the weeds. Three horses were put to the plow in order to make progress, for many of the roots were thicker than a man's thumb. The soil turned over was very friable and required but little harrowing. This plant has a great influence on the character of the soil. The last top-dressing of manure on this field was in November, 1904. Two hundred pounds of a fertilizer containing

Nitrogen	5.5 %
Available Phosphoric Acid	5.0 %
Potash	9.0 %

was applied just before seeding. Three-fourths of a bushel of barnyard millet per acre was sown broadcast with a wheelbarrow seeder, harrowed with a spike-harrow and rolled. A part of the field was cut and made into hay ; the other portion was cut and fed green. The yield, from the measured portion, was 14.3 tons per acre of green fodder. These results are striking when compared with those of the preceding two acres of millet. We should keep in mind that the amount of rainfall at this time made it an exceptional year for the best development of the crop.

Thoroughbred White Flint Corn.

The corn has been very satisfactory, combining as it does desirable characters, such as earliness, succulency and yield. It was planted this season on May 8th and the ears were quite mature for feeding when cutting began, August 4th. Two acres planted June 14th, after cutting a crop of wheat for green fodder, produced a crop of well matured ears yielding 102 bushels (72 pounds per bushel) to the acre. Two acres planted after a crop of crimson clover, made into hay, gave a yield of 93 bushels per acre of sound corn. These two fields were planted in rows 3 feet apart, and quite thickly in the row with the intention of cutting for soiling. Notwithstanding this close planting nearly every stalk matured a good ear. The yield of 12.4 tons of green fodder per acre also compared favorably with the coarser varieties for silage. Experiments in breeding to procure an earlier variety, also to develop a greater yield of forage for the silo; are in progress.

Kaffir Corn and Cow Peas.

Both the red and the white Kaffir corn in combination with cow peas can be grown successfully. The crop can be planted any time after June 10th, and as late as August 1st. This season one acre was planted June 19th and a yield of 12.6 tons of fodder was taken off 78 days after planting. Cutting should have begun a little earlier as the Kaffir corn stalks began to get hard and woody. Red Ripper cow peas 1¼ bushels, and Kaffir corn 12 pounds per acre, are the proportions used. The Red Ripper variety is rather late in maturing, and earlier varieties, such as Whipporwill and Black, would mature at about the same time as Kaffir corn. Very little trouble in harvesting this combination with a mowing machine has been found. If the crop *is cut before the Kaffir corn begins to head,* while the stalk is succulent, a good quality of hay can be obtained.

Cow Peas.

The cow pea is one of our most valuable forage plants. First, *it is a nitrogen gatherer, enriching* the soil *in* that *element* and benefiting the succeeding crop, especially if it is a cereal. Second, a crop of forage will be matured in from 70 to 80 days for soiling and, therefore, can be grown as a second crop, after wheat, rye, or oats, or on sod after the first cutting of grass. One acre of cow peas, Southern White variety was planted broadcast May 22d, 1½ bushels of seed were put in with a grain drill. The soil was dry and apparently in good condition, but only about one-half to two-thirds of the seed germinated. Summer grass came in very thickly and while the yield recorded, namely, 7.6 tons per acre, was fully average, probably over one-half of this amount was summer grass. That the seed was good was proven by a later planting from the same lot. These results plainly suggest *that cow peas cannot be planted in this latitude and soil* earlier than June 10th with any degree of certainty.

Another field of two acres planted to Kaffir corn and cow peas, May 26th, was turned under because of a poor stand and replanted broadcast to cow peas, July 16th, yielding 6.3 tons of

green forage per acre. One acre planted in rows 2¼ feet apart to Gallivant and Clay varieties, a half acre each, gave a yield of 7.5 tons per acre. The difference in the cost of labor by the two methods was $2 per acre. The manures and fertilizers applied to each was about the same. The increased yield of 1.2 tons from the field planted in rows and cultivated, in value would about offset the increased cost of labor, making scarcely any difference in cost of production by the two methods. The inference which may be drawn is that when cow peas are planted early in June in rows as above, the results in cleaner cultivation will be more satisfactory. Later plantings had better be broadcast.

Two acres of red-top and timothy sod were turned under after haying, 250 pounds of fertilizer per acre applied, and planted July 28th. The field kept entirely free from weeds and before cutting was a beautiful sight. The average yield, 5½ tons per acre, was below the production from the other fields, but the difference may be explained by the influence of a hedge of trees on the two sides of the field. Two acres or more gave fully 7 tons of green forage per acre.

EXPERIMENTS WITH FORAGE CROPS.

Experiments with growing different varieties of cow peas to obtain records of yields of forage and seed have been continued. Nine varieties were grown. Experiments with four varieties of millet, sorghum, and sorghum combinations, Milo maize, Kaffir corn, etc., in comparative plots were made. These will form a basis for a bulletin, soon to appear.

II. Field Crops.

Alfalfa.—Six acres newly seeded in August, 1905, were plowed up and seeded to oats and peas. The usual method was followed in preparation and planting. The seed germinated well and the alfalfa looked encouraging in September. In October, blight appeared, and by December 1st nearly all of the plants were dead. It is impossible to give the exact cause, but inasmuch as

a field on a neighboring farm did not blight under largely the same character of soil and climatic conditions, the foreign seed which was planted may have come from infected districts, and the spores brought to the field on this imported seed. Four acres newly seeded last August, two of which blighted the year before, show nothing of it thus far.

Two acres, Plots 22 and 23, seeded in 1903, yielded as follows: 1st cutting, 2.06 tons of hay; 2d cutting, 7.95 tons of green fodder, equivalent to 2.0 tons of hay; 3d cutting, 1.60 tons of hay or a total of 5.66 tons of hay, or 2.83 tons average per acre; *the fourth cutting was not harvested because it matured so late.* In some places the alfalfa is getting thinner, and is being replaced by red-top and mixed grasses. One spot not well underdrained has no alfalfa at all. A four-acre field, Plots 18 to 21, planted in August, 1904, yielded as follows: 1st cutting, 4.65 tons of hay; 2d cutting, 3.70 tons, and 3d cutting, 4.06 tons or an average of 3.15 tons per acre total yield. A portion of the old alfalfa field was taken to enlarge our cattle exercise yard, leaving but $\frac{66}{100}$ of an acre. This yielded as follows: 1st cutting 1.08 tons; 2d cutting, 3.74 tons of green alfalfa, equivalent to 10.98 tons of hay; 3d cutting, .58 of a ton of hay, making a total yield of 2.64 tons of hay or at the rate of 4.0 tons per acre; the fourth cutting was not harvested. This field still yields better than those planted later.

Top-dressing Alfalfa with Lime.

At the close of the last season the alfalfa on one-half of the four-acre field, Plots 18 and 19, was thin and looked sickly, while the alfalfa growing on the other half seemed more vigorous and well-stocked.

In November, 1905, 25 bushels per acre of stone lime, freshly slacked, was applied to Plots 18 and 19. From the beginning of the season a change could be noticed on the limed area. The sickly spots gradually assumed a better color, the plants appeared more stocky and vigorous, and remained free from weeds and grass until late in the season. A sharp distinction could be seen between the limed and unlimed areas. The latter became

Old Alfalfa Field. Yield, 1906, three cuttings, four tons hay.

choked with weeds and summer grass in August, which caused much of the alfalfa to disappear. It became necessary to turn under this sod in the latter part of August.

The results plainly indicate that the alfalfa plant responds to large applications of lime on our soil, and that we must use more lime than has been our practice to maintain permanent fields.

EXPERIMENT WITH ALFALFA SEED FROM WASHINGTON.

Nine large packets of seeds were received from the U. S. Department of Agriculture, Washington, D. C., grown in eight Western States and twenty-three small packets from different countries. The States represented are as follows:

S. P. I. Number.	Agrostology Number.	Source.	Plot.
13,436	2,131	Ontario	1
13,437	2,518	Arizona	2
13,438	2,521	Minnesota	3
13,439	2,530	Kansas	4
13,440	2,531	Kansas	5
13,486	2,532	Utah	6
13,487	2,533	Texas	7
13,489	1,885	Wyoming	8
13,488	2,534	Wisconsin	9

Alfalfa Plots.

The field selected was not the most desirable for this kind c an experiment. It was a newly-purchased piece of ground neglected by different renters, poorly supplied with plant-foo and full of undesirable weed seeds. It was the only field avai able. *Nine plots were selected 13 feet by 304 feet long, with* division of 9 inches between each, sufficient to mark each pl distinctly. Each plot was $\frac{1}{11}$ of an acre. The methods en *ployed were those commonly used and described in Bulleti* 190. Lime was applied at the rate of 25 bushels stone lim per acre. It was inoculated with 400 pounds of soil from ou

old alfalfa field. Fertilizers applied were at the rate of 300 acid phosphate,-100 muriate of potash and 50 pounds tankage: seed at the rate of 30 pounds per acre. A top-dressing of 9 tons per acre of barnyard manure was applied in December.

The seed was planted August 30th. It germinated very well on all plots, but the plants from Ontario and Wisconsin seed did not appear as strong and vigorous. Troublesome weeds from two or three spots were pulled. Weeds appeared very thickly this spring on all plots, especially daisies and shepherd's purse. Attempt was made to pull them but the task was too great and this was discontinued. When the first cutting was ready the weeds so outranked the alfalfa that this plant could not readily be seen and no records could possibly be made, except 80 feet on the ends of each plot where the weeds had been eradicated. This portion was cut June 9th and the yields per plot and per acre are as follows:

	Green Alfalfa per plot.	Green Alfalfa per acre.	Percentage, Kansas 13,439, 100 %.
1. Ontario	90 lbs.	2.15 tons.	60 %
2. Arizona	100 "	2.39 "	67 "
3. Minnesota	130 "	3.11 "	87 "
4. Kansas (13,439)	150 "	3 59 "	100 "
5. Kansas (13,440)	120 "	2 86 "	80 "
6. Utah	125 "	2.99 "	83 "
7. Texas	110 "	2.83 "	79 "
8. Wyoming	110 "	2.63 "	73 "
9. Wisconsin	100 "	2.39 "	67 "

The influence of cutting retarded the weeds for some time and the alfalfa made a more rapid, vigorous growth and largely kept ahead, and even crowded out the weeds. The second cutting was July 13th and made into hay. The results are as follows:

	Alfalfa Hay per plot.	Alfalfa Hay per acre.	Percentage when Utah 13,486 = 100 %.
1. Ontario	250 lbs.	1.357 tons.	96 %
2. Arizona	230 "	1.265 "	88 "
3. Minnesota	250 "	1 375 "	96 "
4. Kansas	220 "	1.210 "	85 "
5. Kansas	220 "	1.210 "	85 "
6. Utah	260 "	1.430 "	100 "
7. Texas	160 "	.880 "	61 "
8. Wyoming	240 "	1.320 "	92 "
9. Wisconsin	180 "	.990 "	79 "

The total yield was at the rate of 1.227 tons of alfalfa hay per acre. This is quite an increase over the first cutting. Most of the plots were quite free from weeds with the exception of wild carrot. The crowns of each plant were considerably enlarged.

The third cutting was made August 25th and made into hay. The records are as follows:

	Alfalfa Hay per plot.	Alfalfa Hay per acre.	Percentage when Arizona is 100 %.
1. Ontario	185 lbs.	1.015 tons.	96 %
2. Arizona	192 "	1.056 "	100 "
3. Minnesota	150 "	.825 "	78 "
4. Kansas	185 "	1.015 "	96 "
5. Kansas	150 "	.825 "	78 "
6. Utah	190 "	1.045 "	96 "
7. Texas	147 "	.809 "	76 "
8. Wyoming	170 "	.935 "	88 "
9. Wisconsin	90 "	.495 "	47 "

The results show quite a wide variation. Selecting the four best plots from each cutting, they rank as follows:

1st cutting, Kansas, 13,439 (1); Minnesota (2); Utah (3); Kansas, 13,440 (4).
2d cutting, Utah (1); Minnesota (2); Ontario (3); Arizona (4).
3d cutting, Arizona (1); Utah (2); Kansas, 13,439 (3); Ontario (4).

The records of another year must be compared with these before any definite conclusion can be drawn. If the results of the three cuttings are totaled, however, the rank will be in the following order: Utah, first; Kansas, 13,439, second; Minnesota, third; Arizona, fifth. The results from this experiment also show that such weeds as shepherd's purse, daisies and wild carrot do not choke the alfalfa plant as will summer grasses, and although these weeds were troublesome, the alfalfa made great gains in crowding them out.

The seed from foreign countries was sown in rows, 300 feet in length and 15 inches apart. The record of planting is as follows:

S. P. I. Number.	Agrostology Number.	Source.
13,519	2,231	Spain.
13,500	2,232	Germany.
13,521	2,233	Algeria.
13 541	2,253	France.
13,542	2,254	"
13,543	2,255	"
13,544	2,258	"
13,545	2,259	"
9,359		Caucasia.
13,547	2,525	Italy.
13,738	2,481	"
13,739	2,482	"
13,742	2,485	"
13,743	2 486	"
13,744	2,487	"
13,745	2,488	"
13,751	2,494	"
13,753	2,496	"
13,754	2,497	"
13,755	2,498	"
13,757	2,500	"
13,768	2,511	Argentina.
13,769	2,512	"

The following failed to germinate :

Number 13,738	Italy.	Number 13,751	Italy.
" 13,739	"	" 13,754	"
" 13,743	"	" 13,755	"
" 13,744	"	" 13,757	"
" 13,745	"		

Number 13,742 proved to be medick clover, medicago lupulina.)nly two out of the eleven samples of alfalfa seed from Italy erminated, or 82 per cent. of poor seed besides the sample which roved to be clover. There was considerable difference in vigor, omparing plants in the same row, from all countries. No ccurate estimate of yield could be made, but the relative yield alling the best 100 per cent. is as follows :

S. P. I. number,		13,519	Spain	36 %
"	"	13,520	Germany	83 "
"	"	13,521	Algeria	82 "
"	"	13,541	France	69 "
"	"	13,542	"	90 "
"	"	13,543	"	84 "
"	"	13,544	"	83 "
"	"	13,545	"	79 "
"	"	9,359	Caucasia	66 "
"	"	13,547	Italy	100 "
"	"	13,751	"	46 "
"	"	13,768	Argentine	69 "
"	"	13,769	"	63 "

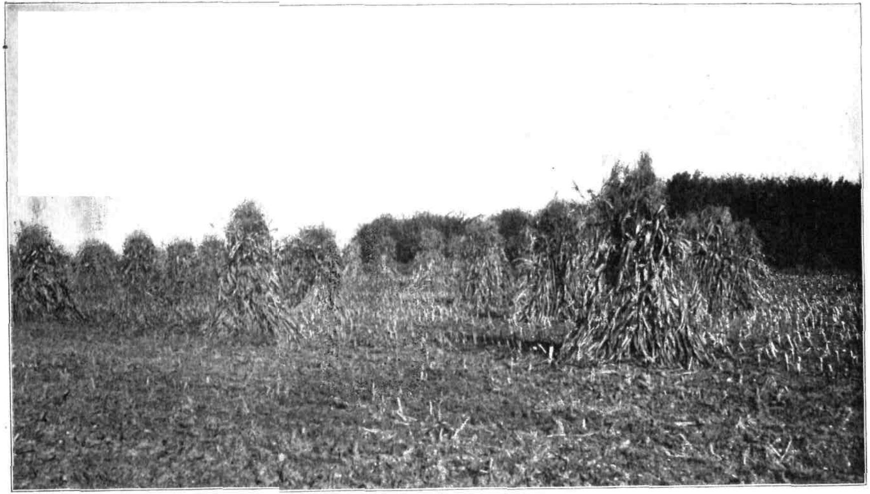
Seed from the most thrifty and vigorous plants was saved an(it is the intention of this department to continue a breeding test

Hay Caps for Curing Alfalfa Hay.

About 30 hay caps were made to study their advantage fo protection against rain. Cotton muslin was purchased whicl would make caps 45 by 45 inches. About two ounces unthreade(bolt nuts were securely fastened to each corner, to weigl down the caps. They could not be blown off, except by ver heavy winds, and seemed to answer the purpose. Old horseshoe could be used if more convenient and economical. The result were very satisfactory and in every case there was a decide(difference in the quality of hay where the cap was used. Som inconvenience was experienced in handling the caps, but thi would be overcome if a light drag were used for collecting an(distributing.

Crimson Clover.—Crimson clover was planted on two acres, F and G, on July 25th, 1905, after a crop of oats and vetch; on(acre (E) sown July 15th as a catch crop in corn and two acres P and Q, also seeded July 18th in corn. The first two acres mad(considerable growth in the fall and covered the ground with a thick mat. That seeded in corn depended for growth and develop ment on the amount of light received. The corn rows were feet apart and where the growth of fodder was heavy the clove was weak. This was noticeable on Plots P and Q planted lat(

5
4



Thoroughbred White Flint Corn, planted after Crimson Clover.

to Throughbred White Flint corn very dense and green in August. The clover did not winter-kill. These fields were all cut the last of May and some difficulty was encountered in curing, as the succulent stem cures much slower than the leaves. The weather was showery and most of the hay was wet but not seriously injured.

The yield was as follows:

Plot E, 1 acre, 1.28 tons; F and G, 2 acres, 2.3 tons each; P and Q, 2 acres, 1.7 tons each of cured hay. The advantage of crimson clover is that the seed can be sown in July and early part of August as a catch crop, without application of plant-food, getting its nourishment from the residual fertilizer applied to the previous crops. The following spring it can be plowed under for green manure, or harvested for soiling or for hay, in time for corn to succeed it. If plowed under and immediately fitted and planted to corn, the mass of green material turned under and the rapid loss of moisture from the looseness of the soil, may hinder the growth of corn so that the influence will be felt throughout the whole season.

Oats and Peas.—This crop is usually required for soiling purposes but this season was made into hay. Nine acres were planted. On three acres the Early Champion variety of oats was sown, and White Spring variety oats on the remaining six acres. The White Spring variety makes a ranker growth of straw, remained green longer, and by the time they were mature for cutting, the peas are past their prime and the pods matured. When the season is moist this difference is not so perceptible.

The Scotch Green variety of peas was planted instead of the Golden Vine as usually purchased. This pea is longer in size and not so economical. This is offset by its ranker growth, many vines being six feet long when cut. This made the crop more difficult to cut and handle, and the hay tedder could not be used for turning.

Brief notice of the different plots are as follows:

Two-acre Plot No. 29, planted April 3d with 2 bushels Chan pion oats and 1½ bushels Scotch peas per acre. This field ha been used several years as an exercise and feeding yard fo cattle and consequently was well provided with organic matte No manure or fertilizer was applied. The growth was rank an required considerable labor in harvesting and curing. Th yield was 5.26 tons of hay or 2.63 tons per acre. The total co of seed and labor including harvesting was $20.16, or $3.83 pe ton of hay.

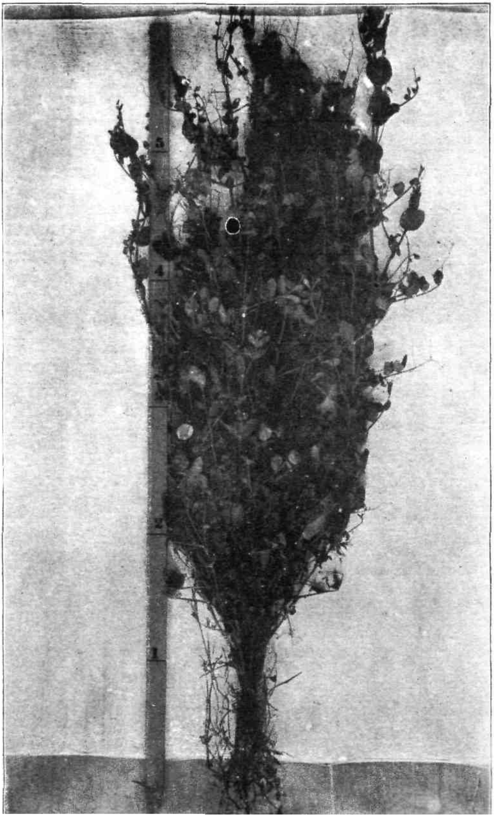
One acre, No. 25, was planted the same day with the sam varieties of oats and peas and harvested June 30th. The yiel was 2.0 tons of hay. Cost of seed, manure, fertilizer and labo including harvesting, was $15.02, or $7.51 per ton of hay.

Two acres, Nos. 16 and 17, a field seeded to alfalfa, which wa killed by blight the previous fall, was planted to White Sprin oats and Scotch peas on April 12th and harvested July 10th 12th. Total yield was 4.25 tons of hay. Total cost of seed, fe tilizers and labor was $26.25, or $6.17 per ton of hay.

Four acres, 1, 2, 3 and 4, planted April 17th, cut July 12tl yielding 8.64 tons, or 2.16 tons per acre. This field had receive good attention; prepared, limed and planted the previous Augus to alfalfa, which blighted. The White Spring variety of oat was sown. Cost of growing and harvesting was $59.47, or $14.8 per acre, making the cost per ton of hay $6.89.

Millet.

The yield of green fodder from Plots 27 and 28, 1¾ acres ha been reported under soiling crops. One acre was made into hay The cutting was begun when its heads were quite mature, bu while the seed was still soft. The growth was very rank and took several days of good weather to cure it. The quality wa good and the yield was 3.25 tons of hay. It is suitable for eithe horses or cattle.


5
4
1

New Seeded Grass.

Eleven acres were planted August 23d, 1905, Plots 5 to 15, inclusive, after soiling crops. Four hundred pounds of Peruvian guano was applied per acre and the seed mixture consisted of 8 pounds Timothy, 4 pounds Red Clover, 2 pounds Alsike Clover and 2 pounds of Red-Top per acre.

No top-dressing was applied the succeeding spring. The seed bed was carefully prepared and planted with a wheelbarrow sower. The stand was even. The yield for the eleven acres was 16.57 tons, or 1.51 tons per acre. The second crop amounted to 20.3 tons of grass, equivalent to about five tons of hay.

FERTILIZER EXPERIMENT WITH CORN.

An experiment was started to study the effect of basic or phosphatic slag as a source of phosphoric acid for field crops compared with that in acid phosphate and Peruvian guano.

The experiment was divided into three plots of three acres each. They received the same treatment the previous season, in respect to manures, fertilizers and crop. Rye had been sown as a catch crop, the previous September and plowed under in April. The Southern White variety of corn was planted.

The fertilizer mixture was made up as follows:

R, S, T, 3 acres (Plot 1)—

Basic slag	400 lbs.	Per acre.
Nitrate of soda	200 "	
Muriate of potash	150 "	

U, V, W, 3 acres (Plot 2)—

Nitrate of soda	200 lbs.	Per acre.
Ground bone	100 "	
Acid phosphate	350 "	
Muriate of potash	150 "	

X, Y, Z, 3 acres (Plot 3)—

Nitrate of soda	200 lbs.	Per acre.
Peruvian guano	200 "	
Ground bone	100 "	
Acid phosphate	200 "	
Muriate of potash	150 "	

All but about 300 pounds per acre was applied broadcast an worked in with a harrow. The rows were 3 feet apart and th stalk averages 8 inches apart. The number of pounds nitrogen, phosphoric acid and potash applied is given in Tab III.

TABLE III.

Amount of Phosphoric Acid Supplied to Each Acre.

	Phosphoric Acid.					
	Plot 1.		Plot 2.		Plot 3.	
	Available.	Total	Available.	Total.	Available.	Total.
	lbs.	lbs.	lbs.	lbs.	lbs.	lb
Basic Slag	....	74.92	....	....	....	......
Ground Bone	....	....	....	24.46	....	2
Acid Phosphate	....	....	46.30	57.60	26.46	3
Peruvian Guano	....	....	....	....	15.64	2
	....	74.92	46.30	82.06	42.10	7

TABLE IV.

Analysis of Fertilizers—Pounds in One Hundred.

	Nitrogen.	Phosphoric Acid. Soluble in water.	Soluble in citrate of ammonia.	Insoluble in citrate of ammonia.	Total.	Potash.
asic Slag					18.73	
round Bone	2.11				27.46	
cid Phosphate		9.88	3.35	3.23	16.46	
eruvian Guano	7.53	2.68	5.14	2.56	10.38	1.89
itrate of Soda	15.27					
furiate of Potash						50.72

The amounts of nitrogen and potash are omitted in the table ince the total amount applied was the same in each plot. The vailability of the phosphoric acid in the basic slag was not letermined.

The plots were planted May 15th and 16th, and cut and put n the silo September 10th–13th. Plot 3 was more matured and the percentage of dry matter was undoubtedly greater. This lot probably has a larger proportion of clay and may have been nore affected by the moist season. The yields were as follows:

Plot 1 .... 43.58 tons or 14.53 tons per acre.
Plot 2 .... 41.26 tons or 13.75 tons per acre.
Plot 3 .... 36.8 tons or 12.27 tons per acre.

The cost of fertilizer on Plot 1, was $31.15, on Plot 2, $34.50 and on Plot 3, $35.10, making the cost per ton, including labor rom Plots 1, 2 and 3, respectively, $1.14, $1.27 and $1.44. It s quite probable that the season and difference in the character of the soil had its influence on Plot 3, and when the amount of lry matter is considered, the total food nutrients from each plot vould be nearer equal. Assuming that the value of feed from ach plot was the same, the cost per ton would be $1.14 on Plot , $1.20 on Plot 2 and $1.22 on Plot 3. These results show that asic slag produced very satisfactory results

Cost of Silage.

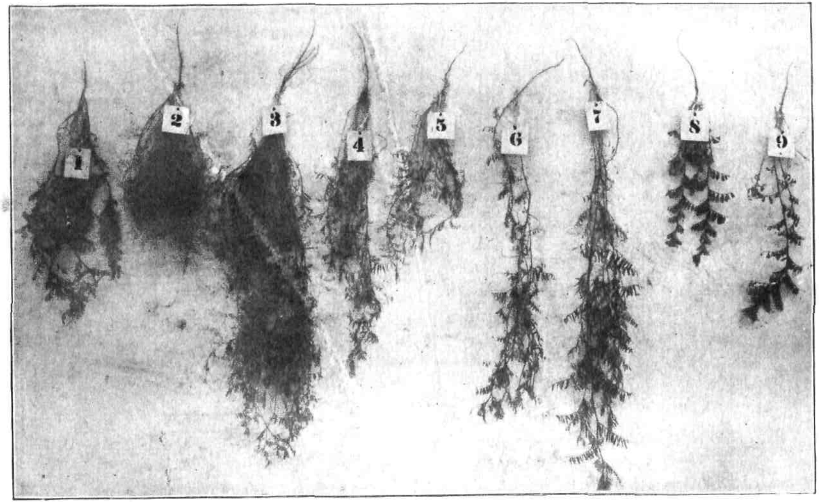
From 18 acres of Southern White corn, 225 tons of foo were cut which filled our two silos. This gave an average y of 12.4 tons per acre. Careful account of the cost of s manures and fertilizers, labor in the field and in filling the gives the following record:

			Yield. Tons.
Plots R, S, T, 3 acres	Seed	$1.44	
	Manure and Fertilizer	31.65	$43.58
	Labor	16.67	
Plots U, V, W, 3 acres	Seed	1.44	
	Manure and Fertilizer	34.50	41 26
	Labor	16.67	
Plot OO, 1 acre	Seed	.48	
	Manure and Fertilizer	2.98	10.42
	Labor	5.55	
Plots X, Y, Z, 3 acres	Seed	1.44	
	Manure and Fertilizer	35.10	36.80
	Labor	16.67	
Plots E, F, G, 3 acres	Seed	1.32	
	Manure and Fertilizer	9.45	42.30
	Labor	17.70	
Lower Field, 5 acres	Seed	2.40	
	Manure and Fertilizer	81.50	51.50
	Labor	27.00	
Total		$323.96	$225.86
Cost per ton of fodder			$1.43

Engine and 2 men	$55.00
Coal	10.00
Team work	91.00
Labor	96.00
	$252.00

Equivalent to $1.12 per ton of corn for cutting and filling.
Equivalent to $2.55 per ton of corn silage.

5
4
3
2
1



Vetches. 1, vicia peregrina; 2, vicia agrigentina; 3, vicia biennis; 4, vicia garardii; 5, vicia ferruginea; 6, vicia globosa;

Experiment With Vetches and Lupines.

Several varieties of vetch and lupine seed were secured from ie U. S. Department of Agriculture, Washington, D. C., with a iew of finding out what varieties, if any, were adapted to our oil, either for green manure or forage. These varieties, Vicia 'illosa, Hairy or Winter Vetch; Vicia Sativa and Vicia Sativa-lba, Spring Vetches or Tares, were planted on 3 plots, one-rtieth of an acre each. Another plot of the same area was lanted to one row each of the following varieties of vetch:

1. Vicia peregrina.
2. " agrigentina.
3. " biennis.
4. " garardii.
5. " ferruginea.
6. " globosa.

All varieties were planted April 28th. *Vicia villosa* was igorous, nearly covering the ground. Blossoming began July th, and on August 24th it was still blossoming and some vines 'ere 3½ feet in length and quite green.

Vicia sativa and *Vicia sativa-alba* germinated well, but early in uly they had made but 4 to 10 inches in growth, affected with light and two weeks later entirely died.

Vicia peregrina.—Large leaf, rather coarse, erect, with no ines, not thrifty, height 18 inches, did not blossom and plants ntirely died August 15th.

Vicia agrigentina.—Small leaf, stem tough, bushy, woody, 10 iches high, may be useful to plow under.

Vicia biennis.—Plant bushy, with numerous branches, early lossoming June 20th, vines attaining length of 2 feet when iature in latter part of July. A promising variety.

Vicia garardii.—Vines trailing, 18 inches long, blossoming 'ell in August, late, not promising.

Vicia ferruginea.—Erect, stiff, woody stems, medium late, roducing white blossoms in July, 13 inches in height, not romising.

Vicia globosa.—Trailing vines, 2 feet, woody, vines matted; ranching, might be used as a catch crop.

Spring Vetch, *Vicia sativa,* has been grown on the farm witl oats and made much better growth than this season. The hairy vetch has been successfully grown with wheat, and the fodde: was greatly relished by the cattle. An experiment, sowing thi: variety in the early fall, is under way.

Further trials with *Vicia biennis, Vicia globosa* and possibl; *Vicia agrigentina,* seem advisable before any definite conclusioı can be drawn.

Four varieties of lupines were planted June 15th in rows anc cultivated:

1. Lupinus augustifolio.
2. " terminus.
3. " albus.
4. " affinus.

Lupinus augustifolio did not germinate. *Lupinus terminu* and *lupinus affinus,* very much alike, 12 to 15 inches tall, blos somed freely; matured and turned dry quickly. They do no seem to be suited to our soils and for us of no practical value.

Experiment With Seeds From Denmark.

The following seeds were received and tested in small plots:

Mangold—Yellow Olive-Shaped Giant.
Carrot—Danish Stensballe.
Carrot—Danish Champion.
Turnip—Danish Yellow Tankard.
Turnip—Danish Gray Stone.
Turnip—Danish New Bronce Top.
Turnip—Danish Tynsk Boetfelder.
Swede—Danish Shepherd Golden Globe.
Swede—Danish Bangholm.

The mangolds, carrots and first two varieties of turnips wer planted April 28th. They were planted on a newly-purchase field, not in good state of cultivation, and no manure was applied The yield is probably below what they would have been on well-tilled field.

The mangolds were solid and smooth, some reaching a lengtl of eighteen inches. The variety seems desirable. Yield abou 15 tons per acre. Both varieties of carrots were desirable, pr

"DANISH CHAMPION"
CARROT
"DANISH-STENSBALLE"
CARROT
YELLOW-OLIVE
SHAPED-GIANT
MANGOLD

ducing an average yield and, while no accurate estimate could be made, the Danish Champion produced approximately 15 per cent. greater yield. Both varieties were tested for cooking qualities, and the Champion, a white variety, was pronounced "very fine." Both varieties of turnips planted in the spring grew rather coarse, were pithy and began to rot in July. It may be that a later planting would have made them more desirable. The Swedes were planted too late to get satisfactory results.

Records of Yield, Cost of Production and Net Income From 76 Acres.

The record of cost includes, cost of seed, manures and fertilizers and labor in growing and harvesting the crops. The value of the crop is the estimate of its feeding value, governed by the market price.

	Yield. Tons.	Cost.	Value.
A and B, 2 Acres.			
Wheat, 1st crop—			
Green Fodder.................	11.94	$17.56	$35.82
White Flint Corn, 2d crop—			
Corn (72 lbs. per bu.)......	102.0 (bu.)	51.94	51.00
Corn Stalks..................	4.5	....	18.00
Total.....................		$69.50	$104.82
C and D, 2 Acres.			
Rye, 1st Crop—			
Green Fodder..	9.4	$10.70	$28.20
Cow Peas, 2d Crop—			
Green Fodder.................	12.6	16.41	37.80
Total.....................		$27.11	$66.00
E, F and G, 3 Acres.			
Crimson Clover, 1st Crop—			
Hay.........................	5.88	$38.98	$70.56
Southern White Corn, 2d Crop—			
Green Fodder (Silage)....	42.30	76.19	169.20
Total.....................		$115.17	$239.76
H, 1 Acre.			
Rye, Cover Crop, plowed under—			
White Flint Corn—			
Green Fodder................	12.4	$28.58	$37.20

	Yield. Tons.	Cost.	Value.
I, J, K and L, 4 Acres.			
Rye, 1 acre, Crimson clover, 2 acres, } Cover Crop.			
White Flint Corn—			
Corn (72 lbs. per bu.)........	166.5 (bu.)	$73.41	$83.25
Corn Stalks.....................	14.0	....	56.00
Total.....................		$73.41	$139.25
M and N, 2 Acres.			
Rye, 1st crop—			
Green Fodder..................	8.8	$24.80	$26.40
Barnyard Millet, 2d crop—			
Green Fodder..................	15.4	38.75	46.20
Total.....................		$63.55	$72.60
O and O1, $1\frac{1}{6}$ Acres.			
Rye, 1st crop—			
Green Fodder..................	4.5	$13.95	$13.50
Cow Peas, 2d crop—			
Green Fodder..................	7.63	24.49	22.89
Total.....................		$38.44	$36.39
P and Q, 2 Acres.			
Crimson Clover, 1st crop—			
Hay.............................	3.4	$12.00	$40.80
White Flint Corn, 2d crop—			
Corn (72 lbs. per bu.)........	93.0 (bu)	34.68	46.50
Corn Fodder.....................	7.36	....	29.44
Total.....................		$46.68	$116.74
R to Z, 10 Acres.			
Rye, Cover Crop plowed under—			
Southern White Corn—			
Green Fodder (Silage)......	132.06	$327.51	$528.24
1 to 4, 4 Acres.			
Oats and Peas—			
Hay (Seeded to grass in August).....................	8.64	$59.47	$120.96
5 to 15, 11 Acres.			
Timothy and Clover—			
1st cutting, Hay..............	16.57	$143.20	$231.98
2d cutting, Grass..............	20.34	25.00	61.02
		$168.20	$293.00

	Yield. Tons.	Cost.	Value.
16 to 17, 2 Acres.			
Oats and Peas—			
Hay	4.25	$30.60	$59.50
Seeded to Alfalfa Aug. 29.			
18 to 24, 6⅗ Acres.			
Alfalfa—			
Hay, total all cuttings	20.4	$142.80	$285.60
25, 1 Acre.			
Oats and Peas, 1st crop—			
Hay	2.0	$14.72	$28.00
Cow Peas, 2d crop—			
Green Fodder	7.55	20.04	22.65
Total		$34.76	$50.65
26, 1 Acre.			
Wheat, 1st crop—			
Green Fodder	7.49	$14.44	$22.47
Kaffir Corn and Cow Peas, 2d crop—			
Green Fodder	12.60	24.48	37.80
Total		$38.92	$60.27
27 and 28, 1¾ Acres.			
Barnyard Millet—			
Hay, 1 acre	3.25	$18.67	$40.00
Green Fodder, ¾ acre	10.67	13.71	32.01
Total		$32.38	$72.01
29, 2 Acres.			
Oats and Peas—			
Hay	5.26	$29.51	$73.64
Triangle, 5 Acres.			
Timothy and Red-Top, 1st crop—			
Hay	10.09	$53.00	$141.26
Cow Peas, 2d crop	26.00	54.97	78.00
Total		$107.97	$219.26
Lower Field, 14½ Acres.			
Corn—			
Green Fodder, 5½ acres	62.44	$180.83	$249.76
Corn, 9 acres (72 lbs per bu.)	172.50 (bu.)	} 300.10	86.16
Corn Stalks	17.98		71.90
Total		$480.93	$407.82
Total, 76 acres		$1,917.49	$3,024.51
Net Gain, $1,107.02.			

Cost of Producing Milk.

No statement was made in the report for 1905 of the cost of producing milk and butter. It is, therefore, included for comparison in the following tables. Roughage was charged at cost of production. Corn distillers' grains were purchased in quantity, and charged at car-load rates, but all other feeds were purchased at retail from local dealers. The calculations, therefore, are from the standpoint of the farmer who purchases only his feed. The soiling system was followed for the six summer months and silage for the remainder of the year.

TABLE V.

Cost of Feeds and Amount Consumed—Two Years.

KIND.	THIRTY-FIVE COWS.			THIRTY-FOUR COWS.		
	APR. 1, 1904, TO APR. 1, 1905.			APR. 1, 1905, TO APR. 1, 1906.		
	Pounds.	Price per ton.	Total cost.	Pounds.	Price per ton.	Total cost.
Wheat Bran	12,800	$23.50	$150.40	29,360	$20.15	$295.80
Dried Brewers' Grain	35,200	21.00	369.60	8,500	22.67	96.35
Hominy Meal	8,000	24.00	96.00	4,640	22.48	52.15
Corn Meal	800	26.00	10.40	1,550	26.00	20.15
Cottonseed Meal	6,400	30.30	96.64	2,475	30.30	37.36
Buckwheat Middlings	11,200	20.50	104.55			
Climax Distillers' Grains				12,360	24.60	152.02
Gluten Feed				10,045	25.30	127.06
Roughage.						
Alfalfa Hay	11,000	6.00	33.00	20,000	6.00	60.00
Peas and Oats Hay				15,000	7.00	52.50
Red-Top and Timothy Hay	12,000	6.00	36.00			
Corn Stalks	24,000	4.00	48.00	25,000	4.00	50.00
Corn Silage	230,000	2.50	287.50	260,000	2.50	315.00
Soiling Crops	340,000	1.95	331.50	309,000	1.95	301.27
Dried Beet Pulp	8,000	16.00	64.00			
Total			$1,627.59			$1,559.66

During the year ending April 1st, 1905, the high price of bran led to the purchasing of buckwheat middlings, and when a good quality can be obtained, this is an economical source of protein. Unfortunately, this feed is often scarce, quite variable in composition, containing a large percentage of hulls. It is not sold on guaranteed analysis. Dried beet pulp was fed for one month in lieu of silage. A larger amount of both feed and roughage was fed that year, with an increase of $67.93, in the cost of food. This increased slightly the cost of milk production.

Approximately 1 ton of feed, 1 ton of corn stalks, 1 ton of hay and $3\frac{3}{4}$ tons of silage for the six months; 1 ton of feed and $4\frac{1}{2}$ tons of green soiling crops for the summer months were required to produce 2,860 quarts of milk or 312 pounds of butter.

TABLE VI.

Proportion of Feed to Roughage.

AVERAGE FOOD.	POUNDS DRY MATTER.		
	Year ending April 1, 1905.	Year ending April 1, 1906.	Average for two years.
Dry Matter in Roughage	4,739	4,664	4,701
Dry Matter in Feed	1,915	1,842	1,878
Total Dry Matter in Ration	6,654	6,506	6,579

The proportions of dry matter consumed per cow was 1,878 pounds in the feed, and 4,701 in the roughage, or a ratio of 1:2.5. The feed ration furnished two-sevenths of the total dry matter.

TABLE VII.

Production of Milk, Fat and Butter.

	Thirty-five Cows.			Thirty-four Cows.		
	Apr. 1, 1904, to Apr. 1, 1905.			Apr. 1, 1905, to Apr. 1, 1906.		
	Milk.	Fat.	Butter.	Milk.	Fat.	Butter.
Total produced (pounds)	220,313.3	9,581.28	11,178.16	217,661.6	9,343.66	10,900.94
Total " (quarts)	102,666.0	....	....	101,430.3	....	....
Average yearly production per cow (pounds)	6,294.0	273.76	319.37	6,401.0	274.81	320.61
Average daily production per cow (quarts)	8.03	....	....	8.17	....	....
Average daily production per cow (pounds)	17.2	.75	.87	17.5	.753	.878

The average yearly production was, 6,294 and 6,401 pounds of milk, and 319.37 and 320.6 pounds of butter, respectively, for the two years, or an average of 6,348 pounds of milk and 319.99 pounds of butter. The average per cent. of fat in the milk was 4.32.

TABLE VIII.

Cost of Milk, Fat and Butter.

COST.	*Thirty-five Cows.*				*Thirty-four Cows.*			
	Apr. 1, 1904, to Apr. 1, 1905.				Apr. 1, 1905, to Apr. 1, 1906.			
	Cost of food.	Milk.	Fat.	Butter.	Cost of food.	Milk.	Fat.	Butter.
		cts.	cts.	cts.		cts.	cts.	cts.
ear average	$46.50	....	....	....	$45.87	....	....	....
	cts.				cts.			
aily average	12.74	....	....	....	12.57	....	....	....
00 pounds	....	73.89	....	....	....	71.66	....	....
pound	....	....	16.98	14.56	....	....	16.69	14.32
quart	....	1.58	....	....	....	1.54	....	....

The cost of feed per cow for the two years was $46.50 and $45.87, or 12.74 and 12.57 cents per day, or an average of $46.19 and 12.66 cents, respectively, per year and day. The average cost of 100 pounds of milk was 72.78 cents; 1 quart of milk, 1.56 cents, and 1 pound of butter, 14.44 cents. This does not include the cost of labor.

TABLE IX.

Average Value of Product and Profit from Herd.

	Average cost of food.	Value.			Profit.		
		Year ending April 1, 1905.	Year ending April 1, 1906.	Average for two years.	Year ending April 1, 1905.	Year ending April 1, 1906.	Average for two years.
Milk at 1c. per lb	$46.19	$62.94	$64.01	$63.48	$16.44	$18.14	$17.29
" " 3c. " qt	46.19	87.99	89.49	88.74	41.49	43.62	42.55
Butter at 18c. per lb	46.19	57.49	57.71	57.60	10.99	11.84	11.41
" " 25c. " "	46.19	79.84	80.25	80.05	33.34	34.38	33.86

At $1.00 per hundred, the price at which milk is sold in some districts, the amount received over the cost of food was $16.44 and $18.14 per year, or an average of $17.29. At 18 cents per pound for butter, the amount over the food, not including labor, was $10.99 and $11.84, or an average of $11.41 per cow for the two years. This, with the manure, represents the amount received from each animal for labor.

From these figures, a cow must produce 4619. pounds of milk, or 257. pounds of butter annually to pay for the food she eats and the only profit, if any, for the labor expended must be in the manure. Even then green forage, silage and hay would be sold for actual cost of production at $1.95, $2.50 and $6.00, respectively, per ton, leaving but little margin for the summer's labor. As a matter of fact, there are many cows scattered throughout the country which produce less than 4,000 pounds of milk and are kept at an actual loss to their owners, without his knowledge, unless he has some system of weighing

the milk, and determining the amount of butter. The expense of keeping records is much less than imagined, and the certainty of knowing what each cow produces gives the owner a chance to eliminate those animals not making a profit.

At 3 cents per quart, the average price received by a large number of producers, the income from the herd was $87.99 and $89.49, respectively, for the two years, giving an average profit or return of $42.55 for the labor.

At 25 cents per pound for butter, a price received by some, the income above cost of feed would average $33.86 for the two years.

The average cost of milk for two years, including labor, interest on and decrease in the value of the herd is as follows:

	Average for two years. 1905–1906.
Foods as per statement	$1,611.62
Labor	750.00
Interest on the herd at 5 per cent	105.00
Decrease in the value of herd at 10 per cent	210.00
Total	$2,676.62
Cost of food per quart of milk	1.56 cts.
Cost of labor, interest and decrease per quart of milk	1.04 "
Total cost per quart of milk	2.60 "

At 3½ cents per quart, the receipts would have amounted to $3,571.68. Deducting the cost of purchased feeds, labor, interest on and decrease in the value of the herd, amounting to $1,869.44, we have a balance, $807.18, which represents the value of home-grown crops. In other words, at 3½ cents per quart for milk, the farm would sell all its produce at profitable prices, namely, hay at $13.45, corn stalks at $8.60, corn silage at $5.29, and soiling crops at $4.19 besides an additional gain represented by 350 tons of manure.

Deducting the cost of labor, amounting to $750, from the total cost of food, leaves a remainder of $1,926.62. Deducting this amount from $3,571.68, or the income from milk at 3½ cents per quart, gives a difference of $1,645.06, which represents the salary received for taking care of the herd.

TABLE X.

Manurial Value of Purchased Feeds.

FEEDS.	Pounds purchased.	Nitrogen.	Potash.	Phosphoric acid.
Year ending April 1, 1905—				
Wheat Bran	12,800	336.6	179.2	36
Dried Brewers' Grains	35,200	1,295.4	302.7	37
Hominy Meal	8,000	132.8	62.4	10
Corn Meal	800	15.4	27.2	[illegible]
Cottonseed Meal	6,400	458.2	128.6	18
Buckwheat Middling	11,200	479.4	245.3	12
Total	....	2,717.8	945.4	1,15
Year ending April 1, 1906—				
Wheat Bran	29,360	772.2	411.0	82
Dried Brewers' Grains	8,500	312.8	73.1	9
Hominy Meal	4,640	77.0	36.2	6
Corn Meal	1,550	29.8	5.3	1
Cottonseed Meal	2,475	177.2	50.7	7
Climax Distillers' Grains	12,360	556.2	38.3	7
Gluten Feed	10,045	419.1	37.2	7
Total	....	2,344.3	651.8	1,21

Table X. gives the manurial value of the purchased fee When these are purchased in large quantities and rich in p tein, the increase of fertility to the farm is an important ite It depends largely, however, upon good management. If t manure is exposed to the weather and consequent losses fr leaching; loss of the liquid portion, by not having water-tig manure pits; or by loss of ammonia from decomposition or de trification, when the manure is allowed to accumulate, the val of the manure considerably decreases. Under good mana ment, it is quite probable that three-fourths of the manurial val

of feeds can be put back on the land. When milk is the principal article of sale, the nitrogen, potash and phosphoric acid in the milk must be deducted.

Allowing the 25 per cent. loss, which may occur in reasonably good management, the increase of fertility to the farm from purchased feeds, with a herd of 35 animals, is equivalent to:

	1905. Tons.	1906. Tons.
Nitrate of soda	6.57	5.67
Acid phosphate	2.74	2.89
Muriate of potash	.71	.49

Assuming that the milk is sold off the farm, the concentrated feeds purchased will furnish an addition of fertility to the farm equivalent to:

	1905. Tons.	1906. Tons.
Nitrate of soda	2.75	1.67
Acid phosphate	1.62	1.79
Muriate of potash	.31	.75

Treatment of Milk Fever Case.

Colantha, a registered Holstein, calved February 7th, 1906. The usual precautions were followed respecting food and a dose of salts was given for costiveness. Apparently she was in good condition. The next morning we found a developed case of milk fever, the cow was staggering and soon dropped, unable to rise. The air treatment was immediately given. A home-made apparatus was used, consisting of a bicycle pump, to which was attached a rubber tube, intercepted near the middle by a glass tube in which was put sterilized cotton and a few drops of creolin. A small glass tube was attached to the end of the tube for insertion into the teat. The glass connection with cotton was sterilized in an oven and the tubing dipped in antiseptic solution. The teats were washed with antiseptic solution, tube inserted and udder inflated *slowly* until well distended. One treatment only was given, and four hours later the animal was on her feet eating. No injurious after effects showed. She quickly responded in milk production and for about three weeks maintained a daily yield of 65 pounds.

Record of the Dairy Herd.

Complete records have been kept of individual animals in the dairy herd, as in previous years, including the yield of milk and Babcock test for fat. The continuity of the records have in a measure been broken, since some animals from abortion, failure to breed, or other causes have not been as profitable. Some were disposed of and new cows purchased to take their places. There are, therefore, but twenty-three complete records for the year ending April 1st, 1906, compared with thirty-three of the previous year.

Three dairy breeds are represented by pure-bred stock, namely, three Holsteins, three pure-bred Guernseys and five pure-bred Ayrshires. The remainder are grade. Five of these are daughters of a grade Holstein, "Queen," which was bred each time to a registered Guernsey sire.

Under "Cost of Producing Milk" are outlined the rations fed and system followed. The milk was weighed morning and evening, and samples were taken every two weeks for determination of fat, and monthly averages of these tests made for basis of calculation. The following table gives the yearly yield of milk, fat and butter. The butter equivalent is derived from the fat by adding one-sixth.

TABLE XI.

Individual Record of Dairy Herd for Two Years.

NAME OF COW.	BREED.	APRIL 1, 1904, TO APRIL 1, 1905.				APRIL 1, 1905, TO APRIL 1, 1906.			
		Milk.	Fat.	Fat.	Butter.	Milk.	Fat.	Fat.	Butter.
		lbs.	%	lbs.	lbs.	lbs.	%	lbs.	lbs.
Hilda	Reg. Holstein	10,945.4	3.84	419.87	489.85	7,498.3	4.59	344.06	401.40
Select	G. Shorthorn	7,621.7	4.34	330.83	385.97	7,304.7	4.12	300.86	351.00
Gypsey	*G. Jersey*	7,238.5	3.95	285.80	333.43	6,804.5	4.12	280.49	327.24
Pearl	G. Holstein	8,720.9	4.23	369.22	430.76	6,080.5	4.18	255.41	297.98
S. Belle	G. Guernsey	4,218.5	5.23	220.75	257.54	4,207.4	5.38	226.79	264.59
Cherry	*Reg. Ayrshire*	*5,517.1*	*4.09*	*225.19*	262.72	7,206.3	4.21	303.70	354.32
M. Perfection	G. Guernsey	5,273.6	4.41	232.75	271.54	4,848.5	4.50	216.11	252.13
Vernie Cooper	Reg. Guernsey	...	...	...	...	4,577.9	4.15	191.04	222.88
Regena 4th	*P. B.* Ayrshire	4,901.8	4.53	222.26	259.30	5,512.1	4.11	225.64	263.25
Queen's Ideal	G. Guernsey	9,313.4	4.36	406.26	473.97	9,427.6	4.40	414.34	483.40
Queen	G. Holstein	7,266.8	3.79	275.32	321.21	5,688.9	3.97	226.20	263.90
Alta	G. Ayrshire	6,435.3	4.19	269.30	314.18	7,116.7	4.42	314.46	366.87
Seboll's 5th	G. Guernsey	4,084.2	5.19	211.95	247.28	4,516.5	5.42	244.23	284.94
Evesta 7th	Reg. Ayrshire	4,583.6	4.28	195.77	228.40	5,043.3	4.28	214.65	250.43
Regena 5th	P. B. Ayrshire	...	...	...	...	5,641.0	4.07	228.27	266.32
Yolande	G. Jersey	3,781.0	3.91	147.82	172.46	5,451.1	4.31	233.47	272.38
Colantha	Reg. Holstein	9,590.4	3.30	316.25	368.96	9,080.9	3.33	298.30	348.02
Buttercup	G. Jersey	5,774.6	4.53	261.77	305.40	4,574.8	4.20	172.52	224.61
S. Daisy	G. Guernsey	7,861.5	4.84	380.73	444.19	4,499.5	5.24	236.30	275.68
Black	G. Holstein	3,694.4	3.93	145.25	169.46	6,193.9	4.16	258.05	301.06
Select 2d	G. Guernsey	...	...	...	...	3,694.0	4.31	178.24	207.95
Queen's 5th	G. Guernsey	...	...	...	...	6,414.5	4.69	300.22	350.26
E. B.'s Felixia	P. B. Guernsey	...	...	...	...	4,754.3	5.51	259.02	302.19
Lilith	G. Jersey	5,523.0	5.99	330.83	385.97	...	...	...	...
Evesta 6th	Reg. Ayrshire	4,018.4	4.11	165.17	192.7	...	...	...	...
Victoria	*G. Holstein*	*5,859.3*	*3.15*	*184.88*	215.69	...	...	...	...
Beula	G. Jersey	7,171.0	4.92	352.60	411.37	...	...	...	...
Zola	G. Holstein	7,160.1	3.96	283.21	330.51	...	...	...	...
Raritan	G. Guernsey	5,162.4	3.74	200.01	233.35	...	...	...	...
Hazel	G. Guernsey	7,281.6	4.46	324.70	378.82	...	...	...	...
Roma	G. Jersey	4,522.6	7.25	327.75	382.38	...	...	...	...
M. Prospect	G. Guernsey	3,004.3	5.23	157.04	183.20	...	...	...	...
Princessa	Reg. Guernsey	6,280.2	4.63	290.83	339.30	...	...	...	...
I. Beauty	G. Guernsey	7,302.8	4.73	345.47	403.05	...	...	...	...
Mijuke	Reg. Holstein	9,214.2	3.48	320.78	374.24	...	...	...	...
Guernsey Ayer	G. Guernsey	4,631.7	5.52	255.65	298.26	...	...	...	...
Q. Delight	G. Guernsey	5,718.0	5.50	314.26	366.64	...	...	...	...
Hospital H. F.	G. Guernsey	5,962.6	4.55	271.07	316.24	...	...	...	...
Average	...	6,261.1	4.38	274.48	320.23	5,919.0	4.36	258.37	301.4

The variation in this table is very noticeable, even with th same animal under the same care in respect to feed and manag ment. The ability of some animals to utilize food and conve it into milk and butter varies with individuals and this varia tion is often spoken of as individuality of the cow. The diffe ence of over 3,000 pounds in the records of Daisy was due t abortion. She was ultimately sold.

The records of the herd have been grouped according to thei production of milk or of butter, showing the cost of feed and ne profit.

TABLE XII.

Profit from Milk.

AVERAGE PRODUCTION FROM COWS YIELDING—	YEAR ENDING APRIL 1, 1905.						YEAR ENDING APRIL 1, 1906.					
	Cost of food.	Number of cows.	VALUE.		GAIN OVER FOOD.		Cost of food.	Number of cows.	VALUE.		GAIN OVE FOOD.	
			At 1c. per pound.	At 3c. per quart.	At 1c. per pound.	At 3c. per quart.			At 1c. per pound.	At 3c. per quart.	At 1c. per pound.	At 3c. per quart.
Over 6,000 lbs. of milk	*$50.25	15	$79.60	$111.27	$29.35	$61.02	$48.50	10	$73.13	$102.13	$24.63	$53.
Between 5,000 lbs. and 6,000 lbs. of milk	48.00	8	55.99	78.27	7.99	30.27	45.87	5	54.67	76.44	8.80	30.
Under 5,000 lbs. of milk	44.10	10	41.44	57.93	-2.66	13.83	43.00	8	44.59	62.34	1.59	19.
Average cow	47.53	33	62.61	87.54	15.08	40.01	45.87	23	59.19	82.41	13.32	36.

*This is approximate, only accurate records to total food consumed were made.

From observation the animals making the best records ar the greatest eaters. At 1 cent per pound the receipts for th year ending April 1st, 1905, from 15 cows, yielding over 6,00 pounds of milk, averaged $79.60, or $29.35 more than th amount paid for feed. The following year, ten cows of the sam class returned an income of $73.13 each, or a gain of $24.63. I is plain that if milk is sold at this price, it will not be profitabl to keep cows producing less than 6,000 pounds, even then th return which represents the amount received for labor, interes

etc., is little enough. At 3 cents or 3½ cents per quart, a price which could have been gotten at wholesale, the gain over food, namely, $53 to $80 each, would net about $1,700 for labor from a herd of 30 cows. A good salary.

At 1 cent per pound, 8 and 5 cows, respectively, producing between 5,000 and 6,000 pounds of milk, made a net gain over food of $7.99 and $8.80, or $30.27 and $30.57, respectively, with milk at 3 cents per quart.

At 1 cent per pound, 10 cows for the year ending April 1st, 1905, did not pay for their food by $2.66 each, while the following year 8 cows made only $0.59 each over the food they ate. At 3 cents per quart, the average gain from this class of cows was but $16.58 each, not including labor and interest.

TABLE XIII.

Profit from Butter.

AVERAGE PRODUCTION FROM COWS YIELDING—	Year Ending April 1, 1905.						Year Ending April 1, 1906.					
			Value.		Gain over food.				Value.		Gain over food.	
	Cost of food.	Number of cows.	At 18c. per pound.	At 25c. per pound.	At 18c. per pound.	At 25c. per pound.	Cost of food.	Number of cows.	At 18c. per pound.	At 25c. per pound.	At 18c. per pound.	At 25c. per pound.
Over 300 pounds of butter	$50.00	20	$68.23	$94.76	$18.23	$44.76	$48.50	10	$64.54	$89.65	$16.04	$41.15
Under 300 pounds of butter	45.00	13	41.36	57.44	-3.64	12.44	44.50	13	46.34	64.37	1.84	19.87
Average cow	47.53	.....	57.64	80.06	10.11	32.58	45.87	.....	54.26	75.35	8.39	29.48

Table XIII. classified the herd into two groups, according to production of butter; 30 yearly records, averaging over 300 pounds of butter each, at 18 cents per pound, gave an average income of $63.38, or a net gain over food of $17.13. At 25 cents per pound for butter, the same animals made a net gain of $42.90 each. Deducting interest on and decrease in value of a herd of 25 cows, the difference which represents the amount re-

ceived for labor, would amount to $1,017, and in addition the skim milk for feeding and over 300 tons of manure.

Twenty-six yearly records, averaging less than 300 pounds of butter each, at 18 cents per pound, averaged $43.85, or $1.15 less than cost of food. At 25 cents per pound for butter, the income would be $60.90, or an average net gain over food of $15.90

TABLE XIV.

AVERAGE.	Cost of food.	MILK.		BUTTER.	
		Value at 3½c. per quart.	Gain over food.	Value at 25c. per pound.	Gain over food.
Year ending April 1, 1905—					
Five most profitable cows	$55.00	$151.44	$96.44	$112.40	$57.4
Five least profitable cows	45.00	60.62	15.62	46.67	1.6
Difference	$10.00	$90.82	$80.82	$65.73	$55.7
Year ending April 1, 1906—					
Five most profitable cows	$53.50	$132.16	$78.66	$97.85	$44.3
Five least profitable cows	45.00	70.10	25.10	57.90	12.9
Difference	$8.50	$62.06	$53.56	$39.95	$31.4

A comparison of the 5 most and 5 least profitable cows is made in Table XIV. In the year ending April 1st, 1906, there were no animals making exceptionally high or low records. The prices, namely, 3½ cents for milk and 25 cents for butter is above what milk and butter would sell for in some rural districts, but no more than could be obtained at wholesale in this vicinity. The 5 best cows for milk production each averaged $96.44 and $78.66, respectively, over what their food cost, while the 5 poorest cows only $15.62 and $25.10, respectively, for the two years. This means a difference of $80.82 and $53.56, or an average of $67.19. In other words, there was an average gain

in profit of 76 per cent. between the 5 poorest and the 5 best animals in milk production.

In butter production, the results are fully as striking. The average gain from the 5 best cows was $50.87, from the 5 poorest, $7.28, a difference of $43.59, or 85 per cent.

In view of these facts, it clearly indicates that there is but little profit in keeping animals producing less than 5,000 pounds of milk and 200 pounds of butter.

REPORT OF THE BIOLOGIST.

REPORT OF THE BIOLOGIST.

This report treats of three distinct subjects, viz.:

I. Experimental Studies in Oyster Propagation.
II. Egg-Production of Virgin Fowls—concluded.
III. An Application of von Behring's Method of Combatting Bovine Tuberculosis.

I. Experimental Studies in Oyster Propagation.

Introduction.

The last Legislature failed to provide the usual annual appro- ·iation* for carrying out the provisions of the act of 1901, lative to the scientific study of oyster cultural experiments. he work was, however, continued by the Agricultural College xperiment Station, which has always borne the principal part ' the expense of these investigations.

Our experimental work in this field was started early, and ·osecuted vigorously throughout the season, with gratifying re- ılts.

A considerable portion of these results are not final, but form e basis of future progress, so that the achievements of any year at may be reported are the outcome of all past experience. Whenever the final success shall be attained, it cannot properly ; credited to the year when it may be reported, but the work all preceding seasons forms one continuous investigation. The timate aim of our experiments is to make it possible to raise 'sters by artificial fertilization in hatcheries, just as is now don ith fish.

THE BARNEGAT LABORATORY.

Last season's work had shown us that at Barnegat were exceptional opportunities for studying natural spatting. In order to properly enable us to make such studies, we erected in May, on Barnegat creek, about a quarter of a mile below the bridge, a laboratory building as an oyster experiment station. It serves as a residence for the biologist, whose continual presence near the spatting grounds is a necessity, and it also "houses" the apparatus and experiments in part. In the winter the small boat, which is a necessity for this work, is stored in it.

The building, shown in the illustrations accompanying this report, was erected on piles driven into the salt marsh or "meadow." Its dimensions are nine feet wide by fourteen long by twelve high. It has an attic story that serves as dormitory, just as in the case of the Tuckerton laboratory. At Tuckerton, however, the dining facilities have been generously offered by Mr. Geo. A. Mott, in his oyster shanty adjoining. At Barnegat these facilities are provided together with the microscopical work table, on the first floor.

This is the second laboratory or station which has been established in accordance with the act of 1901. The first station is that near Tuckerton, at the junction of Stopwater creek and Headley's creek, upon ground the use of which has been given by Mr. Mott.

The Barnegat laboratory is erected on a lot owned by Captain Joseph K. Ridgway. It lies on the creek, at the head of a broad lagoon, produced by the presence of Conklin's island athwart the mouth of the creek. So there are really two mouths to the lagoon, the nearer or northern one empties into Barnegat bay, at the public dock, near Geo. W. Hollingsworth's wharf and oyster house. The distance from the laboratory to the lower end of the lagoon is a good quarter of a mile and it is about the same distance thence to the bay by way of the northern exit. In the lagoon near this exit are two or three islets, known as Cat islands, in whose vicinity are good spatting grounds. There are also good spatting grounds where the lagoon narrows into the northern outlet and again at the actual outlet into the bay. Thus the best of the spatting grounds lie within a half mile of the

laboratory, the nearest being at Cat islands, only a quarter of a mile distant. These grounds also furnish natural oysters of various ages and in spawning condition, suitable for experiments. Some spatting occurs in the creek, from the laboratory towards the bridge. The main road to Barnegat, nearly two miles distant, crosses this bridge, and so the laboratory is easily accessible, as compared with that at Tuckerton.

THE MULLICA STATION.

The main part of last season's work was done at the Barnegat laboratory, but frequent trips were made to Tuckerton and also up the Mullica to Swimming Over, where the Messrs. Sooy have vast oyster plantations of an experimental nature upon riparian grants. Here, and also further up the river, the Sooys have excavated, at great expense, great ditches, twenty feet wide, a thousand feet long and six feet deep, uniting different reaches of the crooked river and through which the tidal currents flow. One of the ditches has been dammed up so as to make a claire for experiments in artificial propagation. These facilities were placed at the service of the biologist, and a certain amount of preliminary experimenting was done, so that we have really added a third station to our list, as it seems advisable to pay more attention to questions that can be solved on the Mullica in the years to come than we have hitherto done.

THE CAUSES OF SLOW PROGRESS.

The difficulties that surround investigation in oyster culture are unusual. That part of the season when eggs, suitable for use in experiments may be secured, is very short. While other lines of research may be prosecuted throughout the year, in our work we are confined to a few weeks. It is true that eggs of some sort were present in the oysters from May to September, but we have good reason to believe that the present season's supply of natural oyster seed was all produced during the last two weeks of June, if, indeed, it was not still shorter.

A second difficulty lies in the fact that the oyster eggs and

young fry are so very small that only powerful magnificati renders them visible to the naked eye. In order to ascerta whether or not oyster fry are present in the water it is necessa to filter it through a fine filter, which is a slow process.

A third difficulty lies in the fact that the oyster is tightly sh up between the two valves of its shell. Nothing can be ascertain of the condition of its spawn, or its state of ripeness, until has been cut open and its life sacrificed. In fish culture t animal may be examined and returned to its cage to await furth maturity.

A fourth difficulty lies in the fact that the oyster lives hidd away in the mud or on the bottom out of sight from above. tonging or raking for oysters, unless the bottom is thickly cover with large oysters, which is unlikely on a natural bed under prese practice, it is quite a task to quickly secure a sufficient number oysters.

A fifth difficulty lies in the fact that the home of the oyster subject to disturbances from storms and tides that often serious interfere with inspection and experiments just when such is mo necessary.

A sixth difficulty lies in the sensitiveness of the oyster changes in its surroundings. We cannot gather oysters and tra plant them close to the laboratory, to be used at our convenien and the needs of the experiments. When so transplanted, t spawn suffers deterioration. Indeed, oysters must be used f experimental purposes within a few minutes after removal fro their native beds.

THE NEED OF LARGER APPROPRIATION.

As compared with experiments in the breeding and propagati of plants and the higher animals, oyster culture presents vast greater difficulties to be surmounted that are only incidental the main problems, but which interfere seriously with the soluti of those problems. In addition to devising experiments f answering such questions as: "What is the proper stage of m turity of the eggs or sperms; what proportion of the male el ment should be added to best secure fertilization; should the eg or sperms, or both, be treated with water before fertilizatio and how long; what density of water is best, and what tempe

ures are most favorable," etc., the experimenter must also devise eans for meeting the natural difficulties above enumerated.

It is advisable that the experimenter actually own an oyster rm of his own; he should have a floating laboratory, anchored ove such a farm. He should have assistants to secure oysters id do other necessary work that presses just when some other periment needs attention. He should have a motor boat to able him to quickly go from one bed to another. Such and her facilities needful for the successful and speedier progress this work requires a more adequate outlay by the State, which e importance of this industry fully justifies.*

LINES OF INVESTIGATION.

In the three localities above indicated, the biologist observed e density and temperature of the water, the time of the tides, e progress of natural spatting, the state of the oysters as regards awning, and at Barnegat, from June 1st to the middle of July, e water was frequently filtered to ascertain the presence or abnce of natural fry. Experiments were made in planting cultch different kinds at different dates and in different situations. large number of fertilization tests were made with a variety of perimental incidentals that solved new problems or more perctly elucidated some that were partly answered. The details these experiments are given in the journal of the experiments. ere we shall call attention only to certain prominent results.

SUMMARY OF RESULTS.

The oysters had begun to spawn by the 19th of May at Bargat. The youngest oysters spawned first. At this date the der "plants" at Tuckerton and on the Mullica were not ripe. y the middle of June the older oysters were spawning in all ree localities.

By the end of June, the large naturals at Barnegat had cometed their spawning. The young oysters were on the point of ginning to fill up with spawn a second time. This spawn,

* An act passed during the Legislature of 1907 increases our appropriation $1,200.

which was thrown out during July, does not seem to have played any appreciable role in producing spat.

A good deal of spawn was present in some of the large planted oysters at Tuckerton and on the Mullica through July. At Tuckerton we made a special experiment in transplanting some of these oysters into a large claire that had been dug the previous year, and from these oysters a fine supply of spawn was gotten up to the middle of August. After that no satisfactory spawn was obtainable.

The new set of natural spat was noticed first July 11th on the Mullica and next day at Barnegat. From various data we concluded that this set had attached not later than July 4th, probably most during the last week in June. There was no later general set, although now and then a straggler was added.

The presence of natural fry was first discovered June 14th, and after June 25th no more was discovered in spite of most diligent filtration of the water.

Dated shells, placed in a special experiment, showed no spat set after July 3d.

The density of the water in Barnegat creek, at first 1.010, fell gradually with fluctuations dependent on the tide until it reached 1.003 by the middle of July. After that date the water was too fresh to permit spawn to live.

At Tuckerton the density of the water in Headley's creek, normally 1.015 to 1.025, started at the normal figures, but gradually fell during the season until, by mid-August, it had reached the exceptionally low figure of 1.007. The density of the Mullica at the opening of the season was 1.010, but by midsummer had reached 1.003.

Only a small proportion of the Barnegat tests resulted in satisfactory fry, and scarcely none made on the Mullica proved satisfactory, but nearly all at the Tuckerton laboratory were highly satisfactory.

The main cause of the failure of artificially produced fry to develop satisfactorily was the use of water of too low a density. This quite fresh water surrounded our fry cages and entered the claire at Barnegat, so the negative results obtained with this part of our experiments are readily accounted for.

The spat which had set before the water became so fresh

emed to stand the later conditions surprisingly well. This is be explained by the fact that the fry now furnished with shells uld shut out the water on the lowest tide when it was least ense, and yet on a flood tide was able to secure sufficient food to ake a fair growth. It must also be noted that the water on e bottom, where the oysters are, is somewhat denser than at e surface, where most of our density readings were made.

In Stopwater creek, and also Headley's, the curious phemenon was noticed during part of the season of the water being ss dense at high water than at low water. This is explained as llows: The tide from Great bay runs up Big creek, thence rough Headley's and Stopwater to a large pond. As the ason advanced, the fresh water from the Mullica river lowered e density of Great bay below that of the pond. Hence in the dal flux there was a period when the water that ebbed out was lter than that which flowed in.

Another unusual occurrence was the presence of a fair set of at in Headley's and Stopwater creeks. Not for more than ten twelve years has a general set been noticed here. This is, ined, a remarkable circumstance, which I have not as yet been le to explain, because, by all that is known about spatting, these eeks should set full of spat every year. The spat were caught fore the unusual density conditions occurred.

Our experiments with cultch showed that oyster fry prefer to tach to oyster shells, and that the inner or smooth side is more vorable to attachment than the outer side. But even the outer de is superior to most other objects. Oyster fry do not show eat choice as between the upper or lower sides, or the hollow convex sides of cultch. Our experiments were, however, mited and this subject is to be more carefully and fully studied.

We found it advantageous to wash our eggs before fertilization. 'e had the remarkable result to secure fry with shells developed, ly twelve hours after fertilization. This was partly due to e prevailing high temperature—usually it takes eighteen to venty-four hours, and if the water is cool the shell stage may even delayed to the thirty-sixth hour. We have previously called tention to the fact that fry may live and appear lively and ormal without shell for days, but such fry will not produce spat.

On the other hand, we noticed that immediately after hatch-

ing, long before there is a sign of a shell, the fry seek the surfac and will cluster on any object that projects out of the water, just in the surface of the water. Here they will rest and develop a fast as do the free swimming fry, and get shells; the shells wil appear as if on the point of becoming cemented to the cultch *We have not been able to raise these fry to a later stage.* Th actual attachment was never completed, but the phenomenon i a noteworthy one. Doubtless, fry attach much sooner after hatch ing than has hitherto been believed, and in that case it must tak longer before they have grown to be visible to the naked eye One planter affirmed that he had seen spat on shells that had bee planted three days. This is certainly a rapid and unusual growth if the observation may be trusted as correct.

OUR OYSTER RESOURCES.

At the close of the section giving the journal of our operations we describe the scene enacted on the natural beds in the Mullic on October 1st, when the new spat are first offered to the public It is a unique sight to see the crowd that gathers to tong this seed reminding one of the crowds that flock to occupy governmen lands newly opened to the public.

The surprising thing about this scene was the limited are upon which the tonger works. Certainly a large part of th bottom of the Mullica is suitable for spat collection if only shell were placed there. This is evident from the results obtaine by the Messrs. Sooy. This vast area hides potential resources o great wealth that are not exploited because the tonger claims th a growth on shells is a natural growth and belongs to the publi But so long as a catch on planted shells is to be considered publi property, just so long nobody will plant shells, and just so lon the citizens and the State will fail to reap the golden harvest. I Holland the oyster lands are State property, but are leased a nually to the highest bidders, and a large revenue is derive while the bottom is cultivated in a most thorough manner.

JOURNAL OF OPERATIONS.

April 25th, 1906.—The erection of an oyster experiment laboratory was begun at Barnegat, as described elsewhere in this report.

May 5th.—The laboratory is so far along that we took up our residence therein and continued the work of preparing the interior fittings.

May 19th, Saturday.—A hot dry day, the end of a week of warm weather. Both air and water are 72° F.

At 9 A. M. some native oysters were secured from the creek near the laboratory. They seemed to be partly "spawned out."

A fertilization test was made with the generative cells of three males and four females. The eggs were washed before the sperms were added.

May 20th, Sunday.—The mercury fell to 62° during the night and rises only to 68° to-day. The water, at high tide, has a temperature of 69° and specific gravity of 1.015 near the laboratory. The experiment glasses of yesterday's test contain hatched oyster embryos that rise to the surface of the water and descend in columns.

May 21st, Monday.—We proceeded to Tuckerton and went to the oyster laboratory at the junction of Headley's creek and Stopwater creek. The oysters planted in the latter by Mr. Mott are filled with spawn which is not quite ripe. Native plants and Hog island oysters on a float are somewhat further advanced in maturity.

The water, at low tide, has a temperature of 70° F. and a specific gravity of 1.015. At high water the temperature is 66° and specific gravity 1.022.

May 22d, Tuesday.—Went to New Gretna and met Mr. J. H. Sooy, who conveyed me in his launch "Enid" to Swimming Over. Here are several immense tide ditches, crossing a neck of land between two reaches of the Mullica river, which were excavated at great expense for experimental purposes. One of the ditches is in process of conversion into a claire by means of dams and gates. The others are planted with shells or with oysters.

Mr. Edward Weber took us onto the river to examine the shells

planted last summer. We found a fair "set" on shells planted before July, but none on those planted later.

The planted natives of large size are filled with spawn, but are not yet ripe. Of those opened, the majority prove to be females.

The temperature of the water at half flood is 67° and the specific gravity 1.010.

May 23d.—We returned to New Brunswick until the 29th, when we went to Barnegat.

June 1st, Friday.—At Barnegat. The water near the laboratory has a temperature of 70° at low tide and a specific gravity of 1.009. We filtered a gallon of it, but found no natural fry present.

June 2d, Saturday.—Air temperature, 74°; water temperature, 72°; specific gravity 1.010, at 9 A. M. The tide is lowest about 1 P. M. At 3 P. M. the thermometer registers 76°.

Captain Joseph K. Ridgway brought native oysters, some from the creek near the laboratory and some from Gunning river. They "open" eight females and five males. The "spawn" seemed scarcely ripe.

At 9:20 A. M. a fertilization test was made after washing the eggs. Rotation of the newly-hatched fry was seen at 4:30 P. M. and by 6 P. M. we had a fine lot of fry forming wonderful descending columns. They were kept over night in a broad dish.

June 3d, Sunday.—At 11 A. M. the fry were transferred to tumblers. At 3 P. M. the air is 76° F.

June 4th, Monday.—The temperature is 74° at noon and 69° at 8 P. M.

We secured oysters at George W. Hollingsworth's wharf, some of which had been taken this morning in Gunning river, and some were Cedar creek "plants" from Mr. Hollingsworth's grounds in the bay.

At 1:15 P. M. we made a fertilization test with the former lot, and at 1:45 P. M. a similar test with the latter.

The fry of June 2d have not yet reached the shell stage.

The shells planted in the creek last season were examined and found to bear a fair "set" of yearling oysters. Scattered among these shells are older oysters that also constitute a natural set, *i. e.*

June 5th, Tuesday.—Strong southwest wind. Temperature 68° in the morning and the maximum in the afternoon is 74°. Tide high about 10 P. M. "Natives" from Mr. Hollingsworth's shelling ground in the lagoon, which had been placed some days ago in the ditch outlet of our claire, were opened at 5:20 P. M. and fertilization test made. The specimens seemed to lack ripeness, two were males and five were females (one in fairly good condition).

Prepared an oyster-fry cage.

June 6th, Wednesday.—70° F. at 7 A. M., 80° at noon, 84° at 3 P. M., 72° at 10 P. M. The tide is highest at 9:30, with a strong west wind blowing.

Water taken near Cat island at high tide was filtered but no fry found, nor were any fry present in water taken near the laboratory. Specific gravity is 1.010.

Fry of June 2d seem to show the beginning of a shell, so, also, the Gunning river lot of June 4th, but the Cedar creek lot are not so far along. Secured fresh "natives" from the lagoon, that furnished three males and ten females, one of which was in fair condition.

June 7th, Thursday.—70° at 5 A. M. None of preceding lots of fry had developed shells. Floated the fry cage at the "point" near the laboratory. Took samples of all tests and planted some in the claire and some in the cage together with cultch, and left samples in the original dishes. We also filled outer compartment of the cage with sea water and returned to New Brunswick.

June 9th, Saturday.—Returned to Barnegat and found that high tides and strong winds had lifted the cage out of its crate and left it dry on the meadow.

Dishes of tests of June 2d and 3d contain only debris. Those of June 5th and 6th contain fry that have failed to reach the shell stage.

Weather is hot with shower in the evening, followed by cooler (72°).

June 10th, Sunday.—Strong south wind, specific gravity of creek water is 1.006 at surface and 1.010 at the bottom, three or four feet below. No natural fry is present. Temperature is 74° in the morning and 78° in the afternoon.

Oysters planted near laboratory last Wednesday show, when opened, that all the small ones have ejected their spawn. The

larger specimens furnished nine ripe males and four females in poor condition. The reproductive elements were infused separately into sea water at noon, and mixed to form the following lots: (*a*) at 12:10, (*b*) at 12:20, (*c*) at 12:30. The tide is high at 2 P. M.

June 11th, Monday.—Wind shifts from west through north to east. Thermometer registers 68° in morning, rises to 70° at noon and falls to 62° at 10 P. M. The temperature of the water is 76° and its specific gravity is 1.011.

The tide is extra high at noon.

The fry lots of June 5th and 6th are still without shell. The lots of June 10th have settled to the bottom. By noon the mantle lobes show, and some, especially in lot (*c*), have deformed shells.

Floated the cage again and planted samples of June 10th lots in it. Poured all of June 5th and 6th into claire.

At 10 P. M. the fry of yesterday are no further developed. Filtration of the creek water shows the absence of natural fry.

June 12th, Tuesday.—Sixty degrees F. at 7 A. M., 62° at 4 P. M. Prepared a second fry cage and floated it in the creek near the laboratory. Also made a float for the claire. The first cage will hereafter be known as the east cage, the second as the west cage.

Secured a lot of natives from the lagoon and found that the young ones had spawned, but the larger specimens seemed to contain ripe "spawn" and furnished seven good females and four males in fair condition. Made fertilization tests as follows: At 10:10 A. M., lot (*a*), both elements mixed in water at once; at 11:45 A. M., lot (*b*), the eggs washed before fertilization; at 1 P. M., lot (*c*), more eggs taken and fertilized with the old sperm water.

At 3:30 P. M. the tumblers were placed in the float. No motion observed at 4 P. M. Samples were planted in the eastern compartment of the west cage.

Found one oyster contained *Bucephalus* parasites.

Left for Tuckerton without separating the fry from the undeveloped eggs.

June 13th, Wednesday.—At Tuckerton laboratory. Tide lowest at 10 A. M.; air temperature, 64°; water temperature, 68°.

Secured a mixed lot of natives and Hog island plants from

Mr. Mott's grounds at Stopwater creek, all filled with nearly ripe spawn.

At 10 A. M., fertilization test made from four specimens of each sex. Northeast storm threatens.

At 3 P. M. went to Swimming Over. Secured some large Hog Island plants from the Round-about, well filled with spawn, and some native plants, from Mr. J. H. Sooy, that had been out of water some hours. These seemed riper than the former.

At 4:30 P. M., made a fertilization test of the above. Air temperature is 62° and the water 69°. The lots were kept in a float until 9 P. M., when they were kept in the launch over night.

June 14th, Thursday.—Found a fair show of fry in yesterday's lots, *but a very heavy sediment of undeveloped eggs.* Samples were planted in the ditch; some were bottled, to be carried to Barnegat, and the balance left in a tumbler.

Returned to Stopwater at 1 P. M. Separated the fry which were not yet in shell stage; bottled some, to be taken to Barnegat; also left some of the Sooy lot in a tumbler alongside of the Mott lot.

Arrived at Barnegat at 5 P. M. We found no shell as yet in the June 12th test, where, on account of cold weather and omission of cleaning, there was only poor development, and many pathological embryos were present. The lot June 10th (*b*) had been in the float since Tuesday, but shows no advance, neither does lot (*a*), but in lot (*c*) are many in fair shell stage. In this case each sexual element had lain in water half an hour before union was permitted.

At 7 P. M., the tide being a third on the ebb, we filtered water from the point and found many natural fry in all stages, including shell stages.

Secured some natives from Mr. Hollingsworth's grounds in the lagoon and planted two-thirds of them in the creek at the outlet of the claire. Opened fourteen oysters and found them in good spawning condition. Selected three specimens of each sex and made a fertilization test at 9 P. M. as follows: (*a*) Small amount of sperms at once; (*b*) larger amount of sperms at once; (*c*) small amount of sperms at 9:45 P. M.; (*d*) larger amount of sperms at 9:45 P. M. Finished cleaning by 11 P. M.

Filtered new lot of water, but found no fry. Air temperature is 70° *at 5 P. M. and 66° at midnight.*

June 15th, Friday.—At 7 A. M. air temperature is 68°, that of water is 70° on low tide, ebbing. No fry found in water from the point. Yesterday's tests result in poor development. Returned to New Brunswick.

June 16th, Saturday.—Made comparative tests of my various hydrometers and determined that at 70° F. the hydrometer used in my experiments reads, respectively, 1.022, 1.010, 1.003, 1.000, .998 with a salinity corresponding to four, two, one, one-half and zero percentage, and that these correspond to readings on the bath dairy thermometer of 120 to 124. At 80° the readings are 1.020, 1.008, 1.002, .9995, .9977. The method of taking these readings is to allow the stem of the hydrometer to be bound by surface tension to the side of the hydrometer flask after it ceases to vibrate, and then to read by an imaginary line joining the lower surfaces of the film on each side and crossing the stem. Care should be used that the surface tension does not exert any friction counterbalancing the weight or the buoyancy of the float.

June 17th–20th.—Commencement and inauguration exercises at Rutgers College.

June 21st, Thursday.—Returned to Barnegat.

June 22d, Friday.—Wind is west. Air temperature is 72° at 10 A. M.; water temperature is 76° and specific gravity 1.012. No shells are present in the debris of lot (*d*) of June 14th.

Prepared cultch for special spatting observation.

June 23d, Saturday.—Wind is southwest and strong. Air temperature is 80° at 4:30 P. M.; 78° at 6 P. M. Tide is rising at 6 P. M. Specific gravity is 1.005 at 78° F. The wind has died down; at 7 P. M. a half-hour's thunder shower pours down. Thermometer falls to 68° at 9 P. M. Tide is well up. Oysters were secured from the lagoon near the laboratory that opened three good males, three fairly good females, six nearly spawned-out females and four specimens that had completed spawning.

A fertilization test was made as follows: (*a*) at 7:20 P. M.; (*b*) at 7:45 P. M., after washing the eggs.

The east compartment of east cage was emptied and filled afresh.

June 24th, Sunday.—Wind calm to light, southeast. Thermometer registers 68° at 6 A. M., 74° at 10:30 A. M., 73° at 2 P. M. The tide is lowest in morning and highest at noon; total range, six inches. The specific gravity was 1.008 on low water at 72° and

1.010 at 10:30 A. M. The water at noon shows 76°. The water in the claire is 68° in the morning, about four degrees lower than in the creek. There is great swarming of newly-escaped "green heads."

The embryos of yesterday's test lie quietly on the bottom of the glasses, but are made lively by addition of new water. Many attach themselves to the tumblers in a ring at the surface of the water, the others continually rise and form descending columns. A glass strip placed on end in a tumbler receives a fringe of oyster fry attached where the surface film rises on the glass.

At 9 A. M. opened seven oysters that were originally secured from the lagoon, but had been transplanted to the creek near the claire for a few days. Secured four ripe males and three ripe females and made a fertilization test as follows: (*a*) at 9:15 A. M., using filtered water; (*b*) at 9:45 A. M., after washing the eggs.

This test produced an enormous swarm of fry at 2:30 P. M., some of which were put into the claire and some into the west compartment of the cage at the point in the evening. Filtration of the creek water shows the presence of many annelid larvæ, some clam fry, a few oyster fry and some animalcules that nearly resemble oyster fry, but have a different motion when swimming.

June 25th, Monday.—The wind is north in the morning, turning to east by noon. Thermometer is 62° at 6 A. M., rising to a maximum at 74° at noon and falling to 70° at 8:30 P. M. Tide turns on first ebb at 2:10 P. M. with specific gravity of 1.011 at 80°.

Test lots of June 23d show fine shell stages, and also apparently an attachment of the fry at the surface of the water to the tumblers and glass strips. Some of these shell fry were planted in the east compartment of the near cage, and some of lot of June 24th in the west box of the point cage.

Filtration of water at highest flood reveals the presence of a few natural oyster fry with shells, much compressed and having a prominent velum.

The shells planted near Mr. Hollingsworth's oyster house, at the mouth of the creek, were examined, but no affixed spat were discovered. Oysters that had been planted on Mr. Hollingsworth's grounds in the bay were opened and found to be well filled with spawn.

At 2:10 P. M. a fertilization test was made of the reproductive cells of one male and three females. The fry were separated at 8 P. M. and glass strips at once placed in the tumblers.

June 26th, Tuesday.—Wind is northeast; tide, medium, at 5 P. M.; air temperature is 65° at 6 A. M.; 72° at 11 A. M.

The fry of June 25th, on surface of the water, became attached at once to an introduced object, such as a glass slide or lead pencil.

The fry of June 24th that were fixed seem to be disintegrating. In the fry of June 23d, in some of both the free and the fixed specimens, the mantle lobes project beyond the shell margin. They are quite flat, and those attached to the glass are easily washed loose and then they swim about. 23 (*a*) is better than 23 (*b*), the former has flat fry with closed shells, while the latter has chunky fry with widely separated valves. The residue of these lots were planted in the west cage.

The creek water, at noon and again at 4 P. M., was filtered, the top and bottom water separately, but no fry were found. The dregs were rich in oyster food, which we put into the tumblers containing advanced fry.

June 27th, Wednesday.—Air temperature is 70° at 6 A. M. 78° at 10:30 A. M., 80° at noon, 75° at 9 P. M. The creek water is 76° warm and 1.003 specific gravity at 10:30 and at noon is 1.002 specific gravity at 80°.

In the afternoon the water, at half ebb, at the mouth of the creek, is 1.010 specific gravity.

Oysters taken off the point near the laboratory have spawned out. T. W. Speck came and photographed the laboratory and surroundings for C. R. Bacon, chief of the Bureau of Shell Fisheries.

Examination of fry lots shows that in June 23d (*a*) hardly any free living fry remaining. The glass slip of June 23d (*b*) seems to have a set of a few spat that are apparently forming a spreading shell. Similar fry are set at surface of the water to slips in lots June 24th and June 25th, but not so advanced.

We placed shell cultch on the float in the claire and in the cages.

We took the oysters transplanted to the crate near the laboratory and found two ripe males and seven females in fair condition.

At 11:15 made a fertilization test after eggs had lain in water a quarter of an hour.

Filtration of the creek water at noon fails to show the presence of fry.

In the afternoon we placed wire holders containing samples of cultch in a vertical position at the mouth of the creek. One set was placed on Mr. Ridgway's shells and one on Mr. Hollingsworth's.

These "collectors" consist of strips of rubber, oilcloth, leather, wood, bark, porcelain, glass, oyster shells, mussel shells, tiles, tin.

At 5 P. M. found lot of to-day forming descending columns; they attach at once to any object at the surface of the water. A homeopathic vial was floated on the water in the tumbler.

The older lots were found badly attacked by infusors.

June 28th, Thursday.—The wind is north in the morning but turns south for the day. The air temperature rises from 70° to 78° F. at 3:30 to 8:30 P. M. and falls to 70° during the night. The tide is high at 5 P. M., the water having a specific gravity of 1.007 at 82°. Filtration fails to show presence of fry. Test lot of June 27th shows the beginning of the mantle, the residue was planted in west box of east cage. The glass strips of lot June 23d (*b*) were floated in the west box of the west cage, and also all the cultch in lots June 23d, 24th, 25th, and planted all the remnants in the claire.

At 7:30 a fertilization test was made with five females and two males from the oysters transplanted to the crate at the outlet of the claire.

June 29th, Friday.—Thunder shower in the morning and at evening, with slight breezes during the day. Thermometer registers 85° at noon and 90° at 4:30. Low water at noon, with a specific gravity at the mouth of the creek of 1.008.

An experimental planting of cultch was made on Mr. Ridgway's shells at the mouth of the creek. Careful examination of bark from new piles and planted shells fails to show a set of spat. Filtration of the water on the eel grass flats north of Cat islands fails to show fry. Examination of natural oysters from these grounds shows that the small oysters are empty of spawn, and the large ones are partly so. Two males and three females with a fair lot of spawn were selected, and at 12 o'clock, noon, a fertilization test was made. The eggs seem to be light and do not settle well during segmentation. The lighter ones were separated and labeled

29 (*b*). Swarming was noticed at 3:45 P. M. The fry stick t[o] an inserted glass slide at once. Some were planted in the east cage

Fry of lot June 27th are very chunky, a few apparently at[-] tached to the glass cultch seem to be growing well, but others equally advanced, swim about in the water film on the slide, show[-] ing that they are not yet cemented fast. This slide was attache[d] to a float and placed in the west cage.

The floated slide from lot 23 shows no fry or spat attached. Lo[t] 28 is now all decomposed.

June 30th, Saturday.—75° F. at daybreak, 85° at 8:30 A. M and 90° at 1:30 P. M. Thunder showers in the evening. Lo[t] 28 (*a*) in the tumbler seems to be growing, though many monster[s] are present. Some water from the claire was condensed by evap[-] oration and added to this lot. Those put into the cage have dis[-] appeared. Lot 28 (*b*) is badly infested by infusors and bacteria Lot 29 has made little or no progress in spatting and growth. A[t] 7 A. M. on the first part of ebb tide a fertilization test was mad[e] on the grounds north of Cat islands. The heavier eggs wer[e] separated from the light ones and form (*a*) and (*b*), respectively Motion begins at 10:30 A. M.

Went to Tuckerton in the afternoon and arrived at the laborator[y] by dusk.

July 1st, Sunday.—The tide in Headley's creek was lowest a[t] 11:30 A. M. with a specific gravity of 1.014, and highest at 6 P. M with specific gravity of 1.011.

About one-half of the oysters were spawned out.

At 11:45 a fertilization test was made of six fairly good female[s] (one well filled with spawn) and four good males. The fry hav[e] risen to the surface at 3:30 P. M. They gather on the side of th[e] tumblers opposite (away from) the window. Arranged fiv[e] tumblers (*a*), (*b*), (*c*), (*d*), (*e*), so that (*a*) contained only a fe[w] fry and (*e*) was most crowded. Then inserted glass cultch.

July 2d, Monday.—Went to Mr. Sooy's grounds at Swimmin[g] Over on the Mullica, bringing samples of yesterday's fry.

At 10 A. M. a fertilization test was made with Hog island oyster[s] near the mouth of Round-about creek. The native plants a[t] Swimming Over were still well filled with spawn and a test lo[t] was prepared after dinner.

A float was loaded with shells and tied in the middle portion o[f]

ditch claire 600 feet long by twenty feet wide by six feet deep. This claire was made by damming up, at both ends, a part of one of the ditches of Mr. Sooy's experiment. Alongside the float a tationary platform holding shells was placed. There was very ittle current in this claire, a little water leaked in and out at each ide, causing a rise and fall of six or eight inches, sufficient to lternately cover and uncover the shells on the top of the platform. These shells soon became rusty red with a deposit from the water, which was turbid in spite of its stillness. Evidently the banks and bottom of this claire were undergoing undesirable fermentations. The specific gravity was 1.003. On this cultch all the lots of o-day and yesterday were poured. On returning to Headley's reek we found that the cultch (*a*), (*b*) and (*c*) held only a few cattering fry, the best set being in (*d*) and (*e*); but most of hem were above the water level and were dried up, due to evaporaion.

July 3d, Tuesday.—Returned to Barnegat. Sultry forenoon with thunder showers after dinner. Temperature is 80° at 3 P. M. and 75° at 3:30. The tide is lowest at 2:30. At 9 A. M., on full tide, the specific gravity is 1.005 near the laboratory. The fry lots left at Barnegat show nothing but debris. At 1 P. M. native oysters were opened on the eel grass flats north of Cat slands and nearly all were found spawned out. A test fertilizaion was made from the little spawn that was procurable.

Rotation of the fry was seen at 3:30 P. M. The best of the lot were planted in the east cage, the dregs were thrown into the claire and the remainder left in the laboratory. Went to New Brunswick; heavy rain during the night, clearing fine and mild during next two days.

July 6th, Friday.—At Barnegat. The tide is highest at 9:30 P. M. with specific gravity 1.010. Both the air and water are 68° F.

July 7th, Saturday.—The air temperature is 68° in the morning and 73° at 5 P. M., at which time the tide is in early flood with specific gravity 1.006 at 70° F. There is a high northeast wind; the tide when high overflows the meadow. The east cage has been swamped, and the cultch on the top platform has been washed off.

All the cultch in the cages and in the claire was examined and

found very slimy. It was all dumped near the west crate, and the cages were cleaned, refilled and received fresh cultch. None of the cultch samples shows the presence of spat, and an oyster put into the west cage had died and was decomposed.

The filtration of low tide water shows no fry present. New cultch was put on the top wire platform. Examination of the fry lot of July 3d shows that all had reached the shell stage, both the free and the attached, but all have died. The best set was found on the under side of slanted slides and on the side away from the light on vertical slides.

A clock-work that would raise and lower the cultch in the water in rude imitation of the tides was set up.

July 9th, Monday.—Rainy day with wind northwest, southeast and south. The thermometer is 68° at 6 A. M. and the highest for the day is 71°, about the same as yesterday. At high water the specific gravity is 1.008 and at low water 1.004 near the laboratory, but 1.010 at the mouth of the creek.

Examination of Captain Ridgway's shells shows two with large spat on, perhaps several weeks old, and many with large crepidulas. These and some oysters were placed into the cages to see if they would live. The fabric of the east cage has a hole eaten through it.

Secured "Hog island plants" on Captain Hollingsworth's grounds in the bay and at 9:30 A. M. made a fertilization test of the spawn from two individuals of each sex. The reproductive elements seem sticky and unripe, much as in the case of similar oysters in the Mullica. Only a few developed, rising to the surface at 4 P. M. These were placed in a vessel in which the cultch was sinking by means of clock-work and would rise in six hours intervals, like the tides.

We then went to Tuckerton.

July 10th, Tuesday.—At Tuckerton. The day proved warm and clear; the tide was highest at 1 P. M., with a specific gravity of 1.012, but 1.015 at low water.

We arranged a clock-work with a tidal cycle of one hour. About a fifth of the planted oysters of Stopwater creek have spawned.

At 9 A. M. made a fertilization test of four specimens of each sex with the reproductive elements of fine appearance. The ova and sperms were taken with unusual care, to prevent contamination from the other tissues, or the juices of the liver and

intestines. They were put into separate glasses of water, and then a few drops of the milt water was added to the roe water. The eggs settle at the rate of an inch each five minutes. Every ten minutes for half an hour about an inch and a half of the upper portion of the roe water was removed and filled up with fresh creek water and at the same time a few drops of the milt water were added. For the next two and a half hours, on an inflowing tide, every ten or fifteen minutes, we drew off the upper portion of the water and filled with fresh creek water. There was an extra high percentage of development, and the fry were forming columns at 2 P. M. This is (*a*). We also prepared three additional glasses of fry (*b*) with one pipetteful of glass (*a*), (*c*) with two and (*d*) with four pipettefuls. Glass (*a*) was placed under the clock-work.

July 11th, Wednesday.—All the test lots of yesterday have reached a fine shell stage of development early this morning in less than twenty hours after fertilization. We secured some of these and took them to Swimming Over and planted them on the shells in the large claire, after washing the cultch.

At 8:30 A. M. a fertilization test was made from four fine oysters of each sex, but a poor lot of fry was secured by noon. These also were planted on the cultch in the claire. A heavy storm threatening, we covered the floating platform with boards, but managed to wash off most of the fry that had been planted.

The specific gravity of the water in the claire was 1.010 while that in the Mullica was 1.007. We returned to Headley's creek and emptied glasses (*b*), (*c*), (*d*) into a bottle which was sent to Swimming Over to be planted on the shells in the claire by Mr. Sooy.

Examination of the planted shells both in the river and in the ditches at Swimming Over showed the presence of a fine set of spat that must have caught a couple of weeks ago, if not earlier.

The glass strips left in the tumblers of the Tuckerton laboratory show a rather good set on the under side of the slanted slides; there was a similar set on the curved side of pieces of a broken glass bottle and on the slide attached to the clock-work, but these had not developed shells. They were set in small clusters of two to four in contact.

At 6:35 P. M. a fertilization test was made from five oysters of each sex. Left next morning for Barnegat.

July 12th, Thursday.—At Barnegat. Temperature about 70° all day. The tide was lowest at 9 A. M. with a specific gravity of 1.003 at 10:30 A. M. and 1.009 at 1:30 P. M.

A boat coming up the creek brought some shells planted off Cat islands for me to examine what seemed to be a set of oyster spat, and so it was. A careful examination of shells planted in the creek above the laboratory failed to show any set of spat. These shells were, however, much more slimy or dirty than those off Cat island.

Examination of the cultch on the wire platform near the laboratory shows but one spat on one shell on the top platform. The other shells having been placed there too recently (July 7th). The dates of all shells earlier than July had been washed off, *except on June 25th. The shells on the middle platform showed* the presence of spat, the latest being on the shells planted July 3d. They are so transparent as to be seen with great difficulty, especially against the white surface of the cultch. Filtration of high tidewater fails to show the presence of fry.

The fry lot of July 9th failed to reach the shell stage and was decomposed. The fry had gathered on the glass cultch, best on the most illuminated side of a slide at right angles to the window, at one side of the window. The uppermost ones were out of water and were dried up. The best set was about a third of the way down.

At 11 A. M. a fertilization test was made from three males and six females that had been transplanted from Mr. Hollingsworth's grounds in the bay to the crib near the laboratory. The spawn was fairly abundant. The method of fractional fertilization that was so successful at Tuckerton was used, but many of the eggs failed to be fertilized, and many, instead of segmenting, became polynuclear. But the eggs were somewhat crowded.

The light and the heavy eggs were separated into lots (*b*) and (*a*), respectively. Most of the polynuclear eggs were in (*b*). The water used in diluting and washing these lots became increasingly denser as the tide came in, and caused an abnormal number of the eggs in lot (*a*) to float. Only a few developed. The fry were swimming at 5 P. M. Lot (*a*) was placed under the clock-work, replacing (*a*) of July 9th. From this lot we also prepared lots (*c*) and (*d*) with glass cultch inclined away from and towards the window, respectively.

July 13th, Friday.—Wind, east; temperature, 68° in the morning, rising to 74° by the afternoon.

Examination of the shells planted around the Cat islands shows that a fine catch of spat is present, but particularly confined to the north end of the little island, and that the set of spat is thinner the farther one goes away from that locality. The most spat was on the hollow or smooth side, whether it was up or down. At low water the specific gravity on these shell beds is 1.010, while at the same time in the creek, at the laboratory, it is 1.004, and in the claire 1.008.

At 10:30 a fertilization test was made with naturals secured near the shelled grounds off Cat islands. The oysters are fully three-fourths spawned out. The fry that developed were separated at 5 P. M.

Tile and brick cultch was placed in the platform.

The fry of yesterday's fertilization had not yet attained to the shell stage.

July 14th, Saturday.—Seventy degrees at 8 A. M. At low water, near the mouth of the creek, the specific gravity is 1.008 and at full flood 1.009. Water at the east cage is 1.006 at half flood and at full flood, at 3 P. M., is 1.008 specific gravity. Half flood water from the mouth of the creek was carefully filtered, but no fry were seen.

Fry lot of July 12th still lacks shells. The glass slips are nearly as well covered on the upper as on their lower sides, having a somewhat wider zone of attachment on the lower side, especially in the slide leaning away from the light. The fry that are the nearest the surface are in the best condition. In the slide attached to the clock-work the zone of attachment is widest, but still covers only a fraction of the entire distance of motion. The deepest fry are most decomposed, as are also most of those on the under surface of the inclined slides.

Test lot 13 is in fine shell stages, both the free and the fixed. A glass strip placed slanting in the tumbler, but at right angles with the window, soon received an attachment of spat on the lower side. These fry showed a distinct development of the dark liver at the umbo. They were about three-hundredths of an inch in diameter. No. 13 was put in place of No. 12 under the clock-work and glass slips were added, standing right and left close to the

sides of the tumbler. The best set was on the side towards the center of the tumbler, on both the right and left-hand strip, and *thus regardless of the illumination but adjusted to the fact of freedom of circulation.* The fry remain attached to the surface, where the strip is lifted out of the water, and are surrounded each by a halo or rim of water. But even in the submerged fry there seems to be a clear rim around the margin of the shell.

Examination of the planted shells on the Ridgway and Hollingsworth flats, at the mouth of the creek, shows a fine set on the former and fewer on the latter, because the current is not so good. Special dated shells were planted at both places. These were not found later.

At noon, in the creek near the "Sans Souci," we raked up some large natives that were all females but one, and some small oysters all males except one. The males were nearly spawned out while the large oysters were filled with spawn. An attempt to make a fertilization test was interfered with by the spilling of the tumblers after all the spawn was secured. Only a few were saved.

July 15th, Sunday.—Thermometer registers from 70° to 73° with an east storm, becoming northeast near night.

Some of July 13th fry were planted on cultch on float in the claire and covered to keep off the rain. The slide under the clockwork (No. 13) was removed as the spat on it were decomposed.

The fry lot of July 14th seems to be not good, no shell has developed.

July 16th, Monday.—Tide low in bay at 10 A. M. and in the creek at laboratory at 1 P. M. The specific gravity of the bay water is 1.009, of the water near Cat islands 1.008 and of the creek near the laboratory 1.002, while that of the claire is 1.005. The morning is clear and calm with increasing southeast breezes starting at 9 A. M. The air is 72° at 11 A. M. and 74° at 1 P. M.

Some of lot 13 were planted in the west box of the east cage, and shell cultch was added to the platform. A filtration of the bay water fails to show the presence of fry. One spat was found on one of the shells taken from the bay, showing that the set here is very slight. Some Hog island plants from Mr. Hollingsworth's grounds in the bay were found to be nearly spawned out.

At 9 A. M. a fertilization test was made from nine males and nine females of these oysters. At 9:15 the fry begin rotation.

After stirring, the upper part of two tumblers of this test was taken off and put into a third tumbler of sea water; then we went to Tuckerton.

July 17th, Tuesday.—At Tuckerton laboratory on Headley's creek. Cloudy morning, with warmer temperature and clearing and increased wind. Tide low at noon. The test lot of July 11th had developed shells, but the fry had decomposed. No shells had developed in the lot brought from Swimming Over. The surface set on the cultch in the tumblers seemed to be a little better on the side towards the window, whether upper or lower side of the inclined strips.

At 12:07, noon, a fertilization test was made from three females and two males in fair spawning condition. The water used was taken on the high ebb in the morning. The eggs were placed in a tumbler of water and received a small amount of sperm water. Then all was distributed into three pairs of tumblers. The eggs settle an inch in five minutes and the water was drawn off and replaced so that about an inch remained, each five minutes for half an hour. At the end of fifteen minutes all except the first pair of glasses received an addition of sperm water, and fifteen minutes later the third pair of glasses received a third addition of sperm water. At the end of forty minutes all the tumblers were filled half full of sea water. The lots were left for the afternoon undisturbed. The tide was full at 8 P. M. and heavy rain fell during the night.

July 18th, Wednesday.—Specific gravity of creek water is 1.012 on high tide. Examination of yesterday's test lots showed that the thrice-fertilized eggs alone had developed shells about eighteen hours after fertilization, and they were better than the others. The twice-fertilized eggs seem to be better developed than the once-fertilized lot. A mixed sample of these fry was taken to Swimming Over on the Mullica.

A "grab" of oysters from Mr. Sooy's ditches showed them nearly spawned out.

At 1 P. M. a triple fertilization was made with fifteen-minute intervals, of the eggs from a dozen females, by sperms from half a dozen males. These and the fry brought from Headley's creek were planted on the float and platform. The shells on the platform were well exposed at low tide at this period.

At 3 P. M. another "grab" of oysters opened up eighteen males, nine females and twelve completely empty of spawn. A comparative test was made as follows: (*a*) Fresh eggs and fresh sperms; (*b*) fresh sperms and eggs left in water half an hour; (*c*) half-hour eggs and half-hour sperms; (*d*) fresh eggs and half-hour sperms.

These were placed outside the house, but unfortunately at sunrise next morning the water became overheated, and the development proved abortive.

Specific gravity of the water in the experiment ditch is 1.007 and only 1.005 in the Mullica at low water.

July 19th, Thursday.—At Headley's creek. Low water at 2:30 P. M.

At 4:30 P. M. examination of oysters placed in the "blind end" of large claire on Headley's creek for some weeks shows two females and three males filled with spawn not quite ripe. Oysters taken from the mouth of Stopwater creek were nearly spawned out, and gave us three females, five males and four empty.

We made a fertilization test as follows: (*a*) Fresh eggs and fresh sperms; (*b*) eggs and sperms a few minutes later; (*c*) eggs and sperms each infused at least a half hour in sea water; (*d*) freshly-taken sperms placed on half-hour eggs; (*e*) three-quarter-hour sperms put on freshly-taken eggs.

The fry were separated from unfertilized eggs at 11 P. M.

July 20th, Friday.—Examination at 5 P. M. of the test lot of yesterday shows (*a*) and (*e*) had reached the shell stage, the others, not having reached this stage, were discarded.

The cultch put into the glasses of July 18th shows that the spat were about decomposed. What was left was in (*c*) where the slides were at right angles to the window. The curved cultch shows best set to be on the concave side with the convexity facing the window.

At 6 P. M. a new lot of oysters was procured from Stopwater creek that opened one male, six females and two empty. A fertilization test was made as follows:

At 6 P. M., newly-secured eggs and sperms.

At 6:30 P. M., newly-secured eggs and half-hour sperms.

Next morning we returned to Barnegat.

July 21st, Saturday.—At Barnegat. The tide was high at 9

A. M. At 2 P. M. the water in the claire was 1.000 specific gravity in the creek near the laboratory 1.006 and at Cat island 1.010.

At 2 P. M. a fertilization test was made from oysters off Ca island. The sperms were left a half hour in water and then a triple fertilization was made.

The fry of July 16th failed to reach the shell stage. The set on cultch in No. 13 had decomposed. The fabric of the cages hac ripped and spilled some of the cultch. The spat on shells placec therein seems to have lived. They were transferred to the claire and the cages dismantled. New cultch was added to the platform.

The shells planted off the shore near the east cage failed to show the presence of spat.

Returned to New Brunswick until July 25th.

July 26th, Thursday.—At Barnegat, etc. Air is 69° F. in the morning; wind, northeast; cloudy; tide high at 1 P. M. The specific gravity in the claire and creek near the laboratory is sc low as to indicate 1.000 on the hydrometer, but off Cat island it is 1.009 on the first of the flood.

At 10 A. M. a fertilization test was made from natural oysters secured at little Cat island. Most of the specimens proved to be males and little spawn was left. The sperms were left half an hour in sea water and then triple fertilization was made of fresh eggs, during washing, occupying about half an hour. The spawn was bottled and taken to Tuckerton, except a sample.

At Tuckerton laboratory at junction of Stopwater creek and Headley's creek. The ordinary oysters were found to be practically empty of spawn, but those that had been transplanted to the large claire were well filled.

At 7 P. M. a fertilization test was made from five males and two females as follows: (*a*) Eggs taken at 7:20 P. M. fertilized by sperms infused twenty minutes; fertilized once, then cleaned; (*b*) eggs taken at 7:25 P. M. and cleaned before fertilization; triple fertilized; (*c*) eggs taken at 7:35 P. M. fertilized once with sperms infused thirty-five minutes and then cleaned; (*d*) eggs taken at 7:40 P. M. fertilized by sperms infused forty minutes and triple fertilized during cleaning; (*e*) eggs taken at 7:45 P. M. and once, after cleaning, fertilized by sperms infused fifty-five minutes.

The eggs seem to be sticky. The air temperature is 70° and the specific gravity of the creek water is 1.012 on a three-fourths ebb.

Examination of the fry of July 19th shows that the fresh eggs fertilized by fresh sperms reached the shell stage. The fresh eggs fertilized by sperms infused three-quarters of an hour were also in the shell stage and very fine. The cultch strip leaning towards the window had good shell "sets" on the under side.

The fry of July 20th were somewhat infusoriated and decomposed. The fry that had fixed to the under side of the cultch leaning away from the window seemed to have attained shells, in the tumbler holding fresh eggs fertilized by fresh sperms.

July 27th, Friday.—At Tuckerton and on the Mullica. Last night's test shows most debris in (*c*) and (*e*) but also most fry. The Barnegat fry of yesterday morning has not yet reached the shell stage. We took samples of both lots to Swimming Over on the Mullica, where the specific gravity in the claire being only 1.006 it became necessary to gradually dilute the samples before planting. At 11 A. M. opened oysters and found twice as many males as females but with a fair showing of spawn.

At 11:15 made an infusion of sperms.

At 11:45 freshly-taken eggs were fertilized by the old sperms, then cleaned with triple fertilization. The lot was not hatched at 2:30 P. M. when planted, but a sample was taken to the Tuckerton laboratory.

An inspection of the planted shells at Swimming Over was made and a very good set of spat found in deep water on the mud, less good in shallow water. The shells planted a year before had fewer new spat on than the shells planted this year, in June.

Returning to Headley's creek, we found, at 7:30 P. M., lot (*d*) of yesterday in the best shell stage; (*b*) comes next and (*a*), (*c*) and (*e*) are poorest. The temperature has been 74° all day.

July 28th, Saturday.—The tide is high at 3 P. M., the air is 78° at noon. An excess of fry was removed from tumblers (*b*) to (*e*), inclusive; (*a*) is a trifle better than (*c*), due to less crowding, and (*c*) is better than (*e*), though many fry are abnormal; (*b*) is better than (*a*) and (*d*) is better than (*b*), though not perfect.

All these shell fry crowd around the edge of the bottom of the tumbler, especially on the side farthest from the window. As the light coming from the window seems to be concentrated by the curved glass and water to the opposite side, I set up a shade on the side towards the window, but the fry still keep on the opposite side, nearest the illumination from the door.

July 29th, Sunday.—Seventy-eight degrees at 9 A. M. The ti is lowest at 10 A. M. A southwest storm breaks at 2:30, with temperature of 77°. The fry lots (*a*) to (*e*) are becoming a normal with no appreciable differences between the five lot They have evidently been crowded, but quite likely the spaw was originally imperfect. All these (No. 26) lots were mix and put into a large flat dish, and rain water was gradual added to the extent of one-half of the original amount.

At 10:30, two dozen oysters from the large claire were open and spawn found in half of them that prove to be four males a eight females. The sperms were ripe in three of the males, b the eggs were not altogether satisfactory.

The sperms were placed into water at 11:35 and the eggs 11:45. A fertilization test was made as follows: (1) Eggs fe tilized once, before washing. Sperms twenty minutes old. (2 Eggs fertilized once, after washing. Sperms thirty minutes ol (3) A portion of (1) thrice fertilized during washing. (4) portion of (2) thrice fertilized after washing.

At 12:30 a fresh lot of sperms was added to a fresh lot of eg before washing; this is lot (5).

The sperms used in (3) and (4) were about an hour old befo the third fertilization was completed.

Nos. (1) *to* (4) *were divided into a new series,* (1*b*), (2*b* (3*b*), (4*b*), in water diluted to the density of the claire at Swi ming Over. Nos. (1) and (3) were divided to make a serie (1*a*), (3*a*), to be gradually diluted by means of siphon wicks ma from strands of cotton cord. Three strands will deliver a dr each seventy-five seconds, seven strands will deliver four drops p minute, but by lengthening the outer limb of the siphon, twent drops fell per minute.

At 3:45 P. M. the newly-hatched fry formed columns in (1*a*) a (3*a*), and all the first series except No. (5). At this time (1*a* and (3*a*) had been diluted only one-twelfth of their origin volume. No. (5) shows columns of fry at 4:35 P. M.

At 4:30 P. M., the fry in (1) and (1*a*) gather in clouds on t side of the tumbler towards the window except when shaded. O shaking the glass, the fry form descending columns. The sa is true of (1*b*) and (2*b*) at 5 P. M., when columns are seen i (3*b*) and (4*b*).

The thrice-fertilized lots seem a little better than the others, and the undiluted glasses than the diluted series. Owing to rowding, a portion of (5) was transferred to a wooden bowl (5b). The fry gather in this bowl on the side towards the light, ut in the tumblers there is a diversity of distributions in the everal glasses owing to varied internal reflections.

At 7 P. M. a fresh lot of debris had collected in the bottom of he tumblers, especially in the diluted glasses and in No. (5). It equired one hour to dilute (1a) and (3a) with the wick of seven trands.

The dilution apparatus on lot No. (26) was now put to work n lot (5b), in the wooden bowl.

July 30th, Monday.—At 10 A. M. Examination of yesterday's ry lots shows the presence of good shell stages in all the lots hat had not been diluted, and none in any diluted glasses, whether radually or suddenly diluted. In (3b) and (4b) columns are till forming, whereas in the undiluted series the fry, weighted by heir shells, were collected on the bottom, especially on the side owards the windows. They were best in No. (1), next (2), ext (3), next (4) and poorest (5). The fry are chunky where ost crowded and are flat in the less crowded glasses.

At 2:30 P. M. Shell fry of July 26th, diluted, are still alive. 3b) and (4b) are now forming clouds only, and breaking up; o, also, are (1a) and (3a). No shell stages seen at 10 P. M.

No. (4) was arranged so as to receive light only on one side, nd the fry gathered on the shaded side.

All the shell fry were now mixed and divided into (6a) and 6b). The former were suddenly diluted, the latter gradually iluted.

July 31st, Tuesday.—The diluted shell fry of July 26th were ow decomposed. The rapidly diluted shell fry of July 29th were n much better condition than those gradually diluted.

All the shell fry except (6a) and (6b) were taken to Swimming Over to plant. In the evening, on returning to Headley's reek with a supply of Mullica water of specific gravity 1.003, e found (6b) in bad shape. We filled up the bowl with the Iullica water. This water was rich in greenish infusors, which ad also developed in our Tuckerton diluted lots. Temperature

August 1st, Wednesday.—A few only of (6*b*) are alive.

Returned to Barnegat in a northeast storm that lasts two days. The sample fry left July 26th failed to reach the shell stage.

August 2d, Thursday.—At Barnegat. High east winds with extra high tides, even at low water; the hydrometer registers 1.000 specific gravity for low tide, even to the mouth of the creek. On the bay side of Conklin's island the specific gravity is 1.007.

August 3d, Friday.—Showery, sultry, windy in afternoon; 79° at 4 P. M.

The cultch experimental plants at the mouth of the creek were removed and examined. The shells were covered with a heavy deposit of sediment, even more than those strewn over the bottom. The shells outside the wire net showed that the set of spat was more abundant on the Ridgway plot than on the Hollingsworth plot, and the same general ratio holds for the cultch in the net. This is to be explained by the better current on the former than on the latter plot.

This apparatus consisted on each plot of two stakes driven vertically into the bottom, to each side of which was nailed a wall of galvanized wire net of one-third inch mesh. The cultch was placed in a vertical position between these walls, and consisted of different objects, none larger than an average sized oyster shell four inches long. The cultch was never exposed at low water and at high tide was covered by at least a foot of water.

The frame on the Hollingsworth plot was two feet long by five inches wide and was placed at right angles to the tidal currents, so that the water flowed through the meshes of the walls and circulated evenly on the sides of the cultch.

A piece of sole leather shaped like an oyster shell, but with the smooth side convex: no catch.

A portion of a rubber shoe, the rubber spread on cloth: two large and one small spat on the smooth side.

A piece of bark freshly chipped from a pine log: nothing.

A piece of brickbat: one spat on the smooth side.

A piece of crockery: three spat on the concave side, one on the convex.

A part of a valve of beach clam: two spat on the convex side.

The flat valve of an oyster shell: eleven spat on the smooth side.

A piece of fresh-tinned ware bent double with the sides a third of an inch apart: nothing.

One valve of a scollop shell, whose outer-ribbed surface favored the collection of sediment: two spat on the smooth inner side and one on the convex surface.

The left or hollow valve of an oyster shell: four spat on the convex, rougher or outer side.

A piece of bright tin rolled up: nothing.

A portion of the bottom of a glass bottle, flat with a flange on one edge: one spat on the flange.

A valve of the black mussel (*Mytilus*) with the convex or outer side westward: five large spat on the inner concave side and two spat on the convex side.

A valve of the black mussel with the convex side eastward: two large spat on the concave side and three on the convex side.

A piece of white pine wood partly wrapped with a strip of carriage "oilcloth:" nothing, but one spat on oilcloth.

A portion of a new cedar shingle: nothing.

A piece of white bowl: one spat on convex side.

A right or flat valve of an oyster bearing the left valves of three smaller oysters attached to its outer or rougher side and projecting beyond its edges. On the smooth side of the large valve are five spat; on the rough sides of the small shells are two spat; on the smooth sides of the small shells are no spat and on the rough side of the large shell are two large spat.

Recapitulation—The following objects bear nothing: Leather, bark, tin, pine wood, cedar wood. The following objects bore spat: Rubber, brick, crockery, clam shell, oyster shell, scollop shell, glass, mussel shell, oilcloth.

Practically as many spat were caught on ebb as on flood tide, and the hollow side had no pre-eminence over the bulging side of collectors. The smooth side of collectors was twice as efficient as the rough side. A mother of pearl or a calcareous surface is most efficient. A horny surface is only half as efficient and a glassy surface a fourth as efficient in the collection of spat.

The frame on the Ridgway plot was only a foot in length and was placed on end, but with the sides facing the current as in the Hollingsworth experiment. Beginning with the topmost object:

The right or flat valve of an oyster: smooth side bears eleven large spat, the outer side thirty-four spat that crowd one another.

A smaller flat valve of an oyster: smooth side, fifteen spat;

A small flat valve of oyster: smooth side, four spat; roug side, fifteen spat.

A large, left valve of an oyster shell: smooth or hollow side seventy crowded spat; outer rough side, thirty-seven spat.

One valve of a scollop shell: hollow side, twenty-four spat ribbed side, thirty-three spat.

One valve of a clam shell (quahog): the hollow or smooth side eight spat; the bulging or rough side, thirty spat.

A piece of crockery partly imbedded in the mud of the bottom eight spat on the upper edge, four on the convex and four spat on the hollow side.

A left oyster valve added at later date bears nine spat on th hollow side and two on the outer side.

A small flat valve in the same receptacle bears two spat on th smooth side and five on the rough side.

The stake holding these frames was of maple with the bark on It was two inches in diameter and projected a foot out of the mud It bore forty-four spat.

The shells on the ground near the stake were covered with more numerous spat on exposed surfaces, but they were not so large a those on our cultch. In this experiment the outer and inner bulging and hollow, rough and smooth, horny and calcareous sides are about equal in value in offering attractive surfaces for spa fixation. It must be noted, however, that the spat were more numerous, there was greater competition, and hence less fastidiousness on the part of the fry. It is likely that had this experiment also contained objects of leather, tin, pine or cedar wood they would have borne spats as did the bark-covered stakes.

August 4th, Saturday.—Hot and muggy. An examination of the shells on the float in the claire shows an entire absence of spat except those on shells introduced. These are still alive in spite of the freshness of the water, but have made little or no growth.

August 6th, Monday.—The weather still continues hot. The thermometer registers 85° at noon. The density of the water at Cat islands is 1.003.

We left for Tuckerton.

August 7th, Tuesday.—At Tuckerton. The tide is lowest in the morning with a density of 1.007, and on high water at noon 1.010 at 80° F., the air being 86° F.

Oysters were secured from the large claire, and out of a dozen were five males, four females, one specimen of each in prime condition, the others only fair or scarcely ripe.

Two series of fertilization tests were made of five glasses each. *In series A the eggs were cleaned twenty minutes before fertilization.* In series B the eggs were taken from the oysters three *quarters of an hour after opening and fertilized before cleaning.* In both series the sperms had been infused into sea water from *a half to two-thirds of an hour when used.* The sets of glasses were treated alike and were started at 8:30 A. M.

First pair: Eggs fertilized with one drop of sperm water.

Second pair: Eggs fertilized with ten drops of sperm water.

Third pair: Eggs fertilized with one hundred drops of sperm water.

Fourth pair: Eggs triple fertilized with ten drops of sperm water.

Fifth pair: Eggs fertilized *once* by small amount of freshly taken spermatic spawn.

Rotation was noticed at 11:30 A. M. Columns *forming in* 2, 3, 4, series A, and by noon in 5, but only faint clouds visible in 1. At noon columns are seen in 1 and 2 of series B, with clouds in the others.

The fry were decanted off at 2 P. M. with debris as follows: Series A, most in 1 and least in 4. Series B, most debris in 5 and 3, less in 1, 2 and 4.

A portion of the fry from each glass was put into a bottle and an attempt made to reach Swimming Over, but head winds drove us back. *Returning* at 8 P. M., we *found fine* shell *stages present* in all of series A and 5 of series B only twelve hours old. On turning out the contents of the fry in the bottle into a broad dish for aeration, it was seen that none had reached the shell stage; on the contrary, considerable decomposition had begun evidently for the lack of air.

August 8th, Wednesday.—At 5 A. M. No shell has yet appeared in series B except in 5, where only a few have reached this stage, but seem to be better than in 5 of series A. In series A the best are in No. 2, next best is 4 and third is 3.

Some of the fry in the dish have recovered from their experience in the bottle and have attained the shell stage. The best of all these fry were planted on cultch on a float in the big claire.

Returned to Barnegat, where photos were taken by T. W. Speck, of Tuckerton, of the laboratory and operations. At Barnegat we found that the majority of the natural oysters near Cat islands still contain spawn. Returned to New Brunswick.

August 11th, Saturday.—At Barnegat. The water at Cat island is now practically fresh. The water from the bay had a specific gravity of 1.006. Taking oysters at Cat island, made a fertilization test allowing eggs and sperms to lie separate in water from twenty minutes to half an hour, as follows:

1. In water from Cat island, at 7:45 A. M.

2. In water from Cat island, after filtration and no fry were found, at 9:15 A. M.

3. In water from Cat island gradually strengthened by bay water, 1.006 specific gravity, at 7:45 A. M.

4. In bay water, 1.006 specific gravity, at 8:30 A. M.

Thermometer at 9 A. M. reads 80° F.

At 2:30 P. M. there was no development except in 4.

August 12th, Sunday.—At 8 A. M. found good shell stages present in No. 4, but quite flat and with extra big "foot." These fry, however, undergo gradual decomposition.

August 13th, Monday.—Cooler this morning. The water on a tide little more than half out has a density of 1.003 at Cat island and 1.005 in Barnegat bay. Left for Tuckerton.

August 15th, Wednesday.—At Tuckerton. Last night and this morning are cool, but by 2 P. M. the thermometer registers 77°, at which time the tide is nearly half in and the water is also 77°. At 3 P. M. the specific gravity of the water is 1.007 and at 4:30 1.009. At 8:30 P. M. the air is 70° F.

At 3 P. M. six oysters from the large claire were opened. Two contain no spawn, two are ripe males and two are ripe females in very fine condition. At 3:35 the eggs and sperms were separately infused into water of 1.007 specific gravity, and the eggs were cleaned at 3:45 and 3:55. They were then distributed into five tumblers having about an inch of water in each.

At 4 P. M. each glass was fertilized by addition of ten drops of sperm infusion and one or two drops added each five minutes when cleaning until thrice fertilized.

At 4:15 P. M. more eggs were taken from the specimens placed in tumbler No. 6 and fertilized at once with ten drops and thrice fertilized with a small amount during cleaning.

As the tide comes in the water becomes denser and this w was added to the series. A large proportion of eggs were cai to float and these were taken from each glass and put into a sec series. At 8:30 P. M. no fry have hatched.

August 16th, Thursday.—At 7 A. M. the temperature is ' at 1:30 P. M. 80° and at 8 P. M. 77°. The specific gravity of first inflow tide is 1.008. Highest water at 7 P. M. Nos. 5 of the first series of yesterday's test show columns of fry No. 6 shows clouds. At 1:30 P. M. all of the first series ex No. 6 have reached the shell stage, with the fry heaped up the bottom on the side towards the window.

After stirring, the fry that settled first were drawn off planted on the cultch floating in the claire.

August 17th, Friday:—None in the second series reached shell stage. Additional good shell fry were planted on the fl ing cultch and the balance were taken to Swimming Over planted on the cultch in the claire there. This water ha specific gravity of 1.003 while that in the river is 1.001. turned to Headley's creek.

A fresh supply of oysters was taken from the Stopw "plants," to be placed in the large claire to observe the effect transplanting. On opening some of these oysters, we found t were through spawning.

A few of the fry in the second series have reached the s stage, but are monstrosities.

August 18th, Saturday.—Returned to Barnegat.

August 20th, Monday.—At Barnegat. The water is still fr in the creek near the laboratory, and only 1.002 specific gra at Cat islands and 1.005 specific gravity at low water on the side of Conklin's island. Some of the bay water was secured oysters were opened and fertilized near Cat islands, using naked eye alone to determine the sex and character of the spa Not quite satisfactory, some of the oysters were brought to laboratory, opened and their spawn added to the first lot, at A. M. These were then distributed into five tumblers. ' temperature was almost steadily 80° for the day.

The platform experiment was examined and the appara taken up. This consisted of a crate with three decks of v netting, holding shells, sunk and anchored near the east oy

The shells on the top platform were thoroughly coated by a growth of moss of a bright green color. Those on the middle floor were partly covered by a mossy growth of a brownish color. The shells on the lowest floor were clean. The shells on the top floor carried no spat and of those on the middle floor only one, a clam shell, had any spat on. The shells on the bottom deck all bore spat, not very thickly but more so than on the shells lying on the mud or bottom in the vicinity.

The spat on the shells at Cat island seem to stand the fresh water very well.

Some yearling seed that had remained in the claire all summer was now removed and found to be alive, except in some instances. Returned to Tuckerton.

The remaining work consisted in dismantling my apparatus, packing specimens, etc., and will not be described as a daily journal. Two additional trips of observation were made from New Brunswick, one September 6th and one September 29th. At the former date the water at Barnegat was still quite fresh in the creek, being 1.002 specific gravity, while it was 1.007 in the bay. By the end of September it had regained its normal salinity of 1.010 at Cat island. The water had proved too fresh near the laboratory to permit of a successful natural set or even to permit of a half development under artificial conditions.

At Tuckerton the water was unusually fresh in Headley's creek owing to the extraordinary freshness of the Mullica water which lowered the density of Great bay, but this river recovered its normal condition by the end of September. During a considerable portion of the summer the unusual feature of the water being actually of lower density at high tide was seen at Headley's creek, but this became corrected though the density was unusually low even on the last day of the month of September, not exceeding 1.012.

Another unusual occurrence in Headley's creek was an abundant natural set of spat on the shells, planted oysters, rockweed, etc., wherever the currents were favorable.

The oysters planted in the large claire August 17th, which contained no spawn, showed the following condition September 10th. Those nearest the blind end of the claire had died, while those in the middle showed traces of spawn. Earlier in the season such a

transfer had proven successful in the production of the "spawny" condition.

The last trip of the season was made principally to observe the taking of oysters from the natural beds, the so-called "gravellings," in the mouth of the Mullica river. On the first day of October these beds are thrown open to the public.

Here were over a thousand boats of all kinds from large schooners to small yachts and launches intersprinkled with the more numerous garveys. The boats that were "buying" advertised the fact by hanging a basket in the rigging. When a garvey was loaded it was pushed to the nearest buyer, the catch measured, transferred and paid for on the spot.

It was evident that the rich beds were limited in extent or it would not have been necessary for the boats to work so closely together. The larger of the two beds, according to the dimensions of the area covered by boats, must be judged to be about a third of a square mile in size, and the smaller only about a quarter of a square mile.

Only a mile and a half above these beds, where the Sooys have shelled riparian grants, it has been demonstrated that nearly every part of the bottom is good for catching natural spat. Doubtless many square miles of the Mullica could be transformed into productive natural oyster-ground if only private enterprise in raising natural seed were encouraged. But as the State would have to protect private enterprise, it could justly tax such property to meet this expense. The result would be a large increase in the industries of the State, in the demand for labor, in the food supply, in the shore population, in the general prosperity.

I was informed that the total estimated yield of the gravelling beds this season was 200,000 bushels, which gave a remuneration to the tongers of $40,000, a production far below the yield of these beds many years ago. So long as the cultch holds out the beds will not become extinct. They should be accurately staked out and left as public property. All the remaining area of the Mullica should be let to private enterprise to develop its resources, which may equal a hundred thousand dollars per square mile.

EXPLANATION OF THE PLATES.

PLATE I.

Map of the vicinity of the Barnegat oyster laboratory. Bodies of water of considerable extent are left white. The marsh land is closely dotted.

A. Tuckerton railroad station.
B. Central railroad station.
C. Artesian spring.
D. Bridge over Barnegat creek.
E. Hollingsworth's large oyster-house.
F. Oyster laboratory.
G. Cat islands.
H. North mouth of Barnegat creek.
I. South mouth of Barnegat creek.
K. Location of oyster cage in 1905.

PLATE II.

View of the Barnegat oyster laboratory with one of the oyster fry cages, which has seen service, near the experimenter.

The western oyster fry cage lies in the creek at the left, just outside the field of the camera.

PLATE III.

Interior view of the Barnegat oyster laboratory looking north, showing the microscopical work bench with tumblers and other tools used in oyster-cultural researches.

PLATE IV.

View of the western oyster fry cage and crate. The experimenter in his boat about to determine the density of the water, and Barnegat village in the distant background.

PLATE V.

View of the Tuckerton oyster laboratory.

1. Mr. Mott's oyster shanty, used as dining-room.
2. Incubator house.
3. Laboratory and dormitory.
4. Frame over the old claire. The new "large" claire lies to the left, outside the field of the camera. Stopwater creek runs behind the buildings. A part of the gate at the mouth of Stopwater is seen at the extreme left with a view of the trees on Hickory island on the horizon.

PLATE VI.

The experimenter tonging oysters at the gate, in the mouth of Stopwater, which here empties into Headley's creek. The trees on Hickory island are in the central distance, looking westward. Beyond the horizon, to the left, is the Mullica river.

PLATE VII.

Opening oysters for experimental purposes with side-cutting pliers.

PLATE VIII.

The set on the cultch on the experimental platforms.

1. Oyster shell from the top platform bears only moss.
2. Clam shell from the middle deck bears a few spat and is much covered by a dark dense deposit or growth.
3. Oyster shell from the lowest deck well covered with spat. This was shaded so it kept clean. Most abundant set on the rough convex side of shell which was probably uppermost.

PLATE IX.

Barnegat cultch with spat of different ages.

1. Shell with freckle-like spat taken July 12th.
2. Same "set" of spat, July 26th.
3. "Set" of spat, July 27th, from the Mullica.
4. "Set" of spat, July 27th, from the Mullica, showing spat of the year preceding, bearing spat of the present season.

PLATE X.

Barnegat spat of various ages.

1. Spat taken September 29th, Cat island.
2. Spat taken September 8th, Cat island.
3. Spat taken August 6th, Cat island.
4. Spat taken August 6th, Ridgway plot.
5. Spat on part of bottle, September 29th, Ridgway plot.
6. Yearling oysters, Cat island, September 29th.
7. Spat from Cat island, September 8th.
8. Spat from Cat island, September 29th.

PLATE XI.

1. Bottle containing both within and without a set of oysters bearing later set of spat.
2. Side view of a Barnegat natural cluster of "stick-ups."

PLATE XII.

1. A Barnegat natural cluster of oysters of each season for half a dozen years.
2. A smaller cluster on the back of a shell, also showing several

PLATE XIII.

1. A bunch of rockweed bearing a natural set, secured Augus 24th in Headley's creek.

2. Natural gravellings seed, October 1st, 1906.

3. Part of a lath from the crate of 1905 off Conklin's island bearing a natural set. Although this had been thrown on land by some wintry storm, the oysters had time to grow to a relatively large size, showing how much more rapid the growth is when the oyster is elevated above the bottom. Also, how much faster the growth is when the cultch offers a large surface and no crowding

PLATE XIV.*

Eggs hard boiled and split lengthwise. From the eggs laid by hens in pen I. and pen II., respectively, fertilized and unfertilized. These eggs were kept stored in a box in an office from January to October. Those in upper row were laid late in January and February, the second in March and April, the third in May and June, the fourth or bottom row in July and August. The large end where the air-chamber is, is turned towards the top of the page. The plate illustrates the rapid loss of weight by evaporation when the eggs are not kept in a damp atmosphere or in tight receptacles. Had these eggs been kept on moist, cold earth and covered, they would doubtless all have kept perfectly well. The mould spores and other germs entered the air-chamber and flourished there, but only to a slight extent, scarcely perceptible in the photos. The right-hand egg in the third row evidently lay on its side during evaporation.

* This plate illustrates Part II. of this report, which follows.

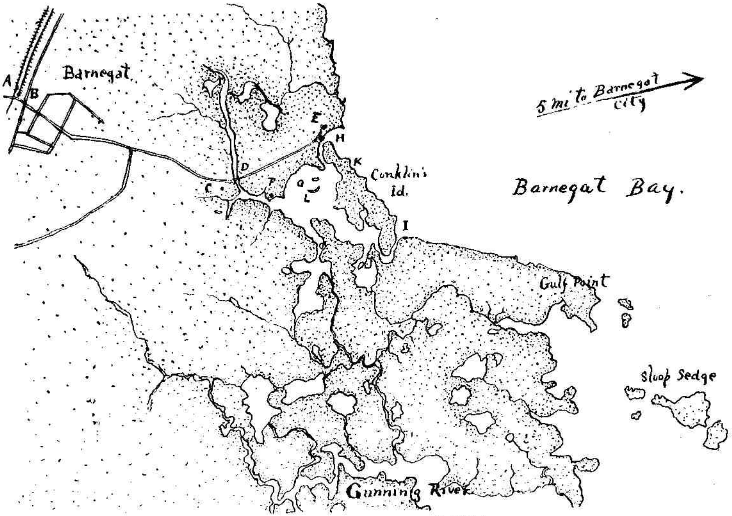
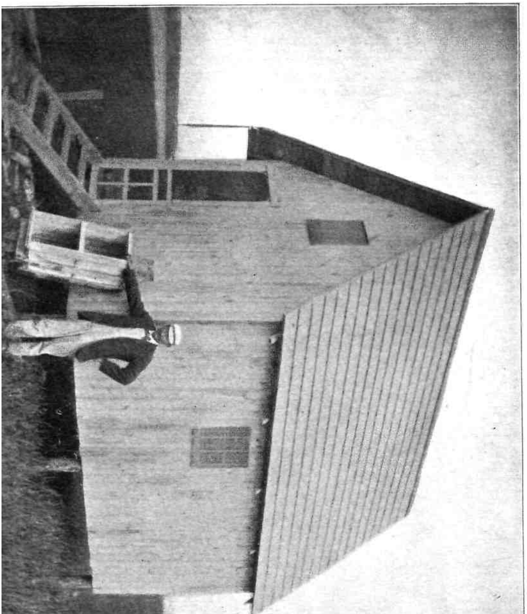
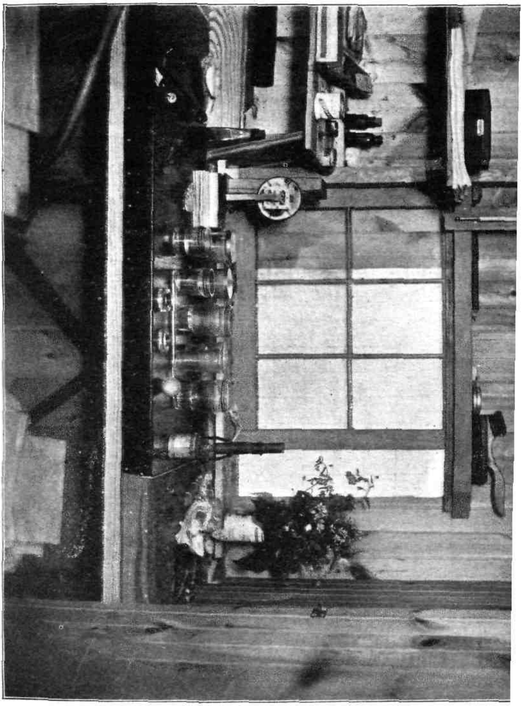

Barnegat
A
B
C
D
E
H
K
P
Q
L
I
Conklin's Id.
Barnegat Bay.
5 mi to Barnegat City
Gulf Point
Sloop Sedge
Gunning River

PLATE I.





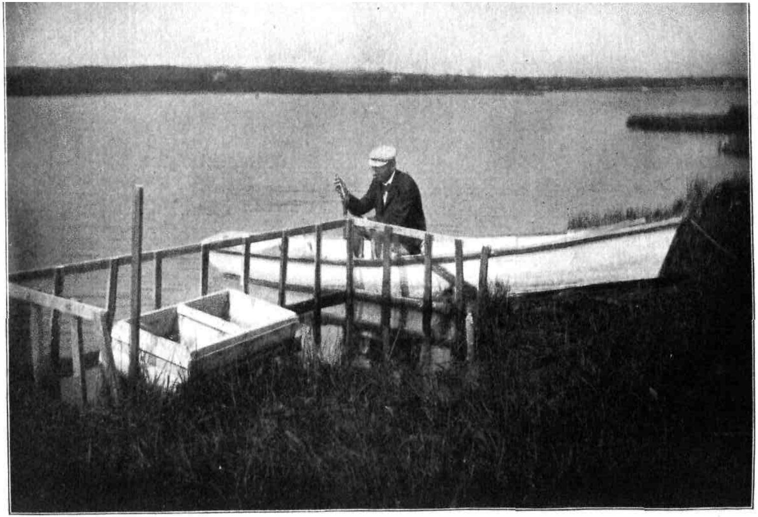
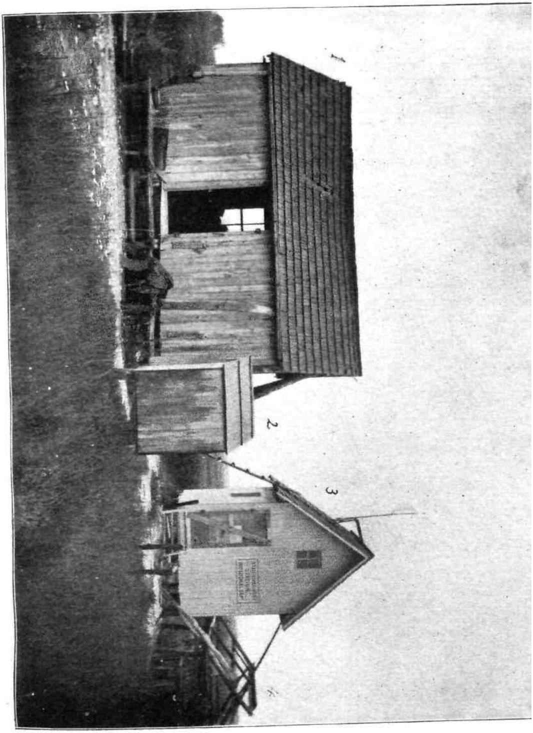
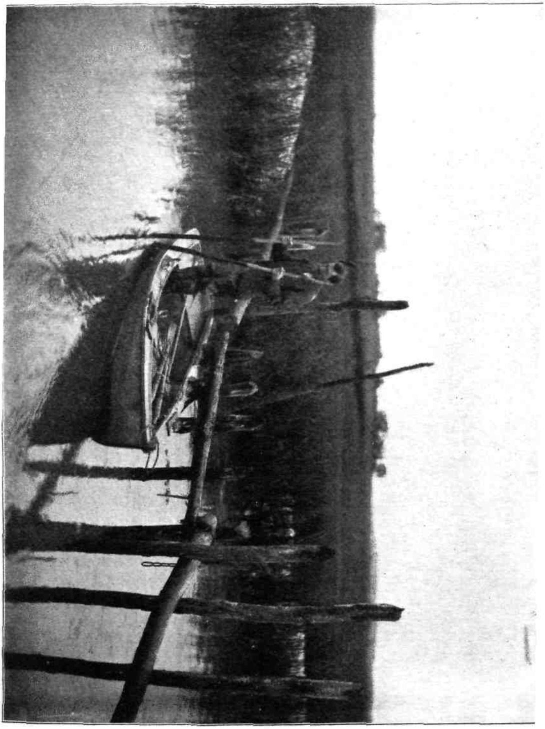
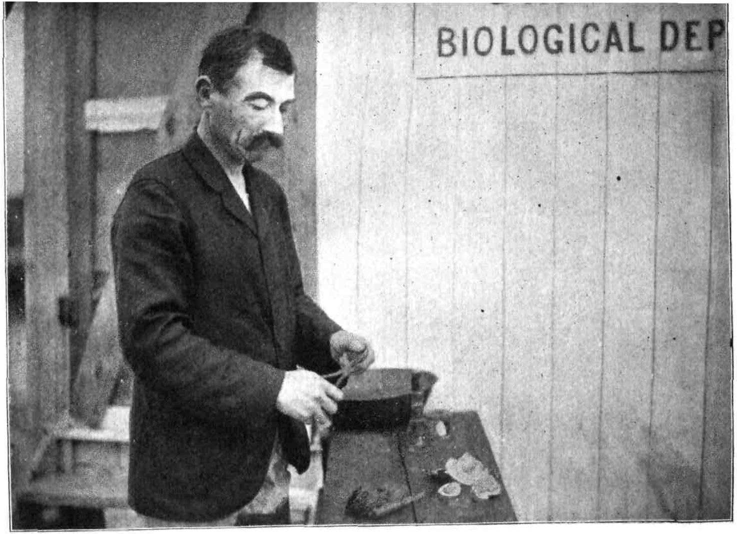
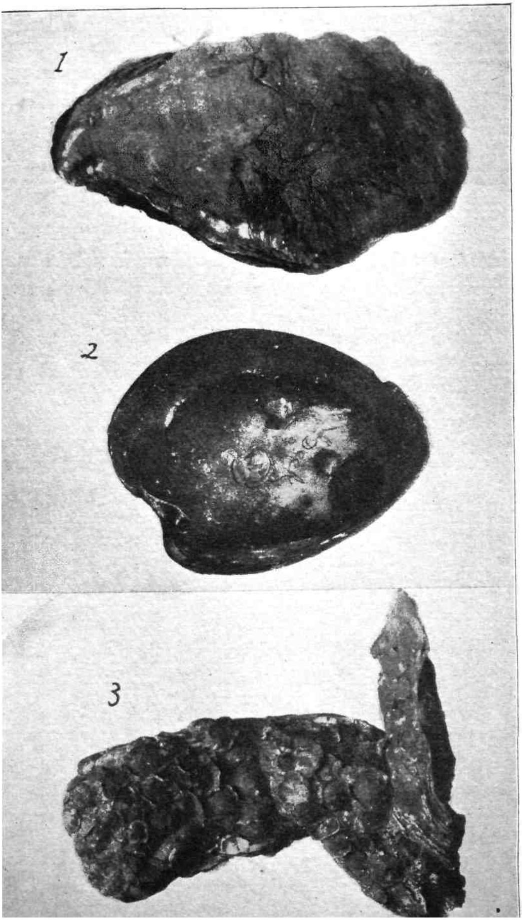


PLATE IV.


1
2
3




BIOLOGICAL DEP


1
2
3

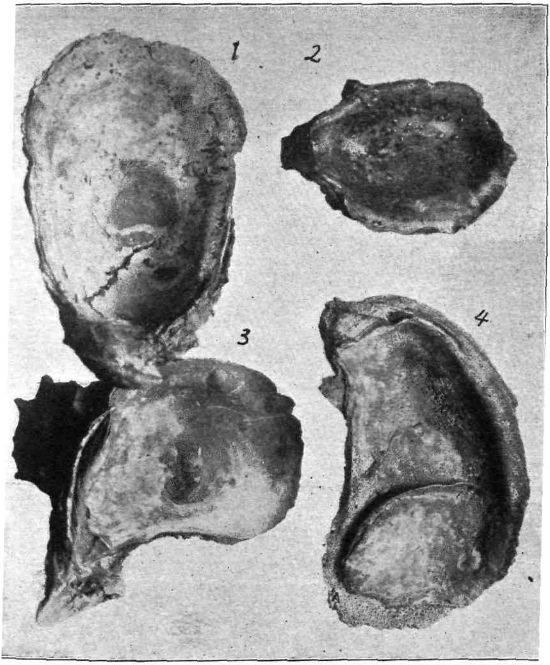


PLATE IX.

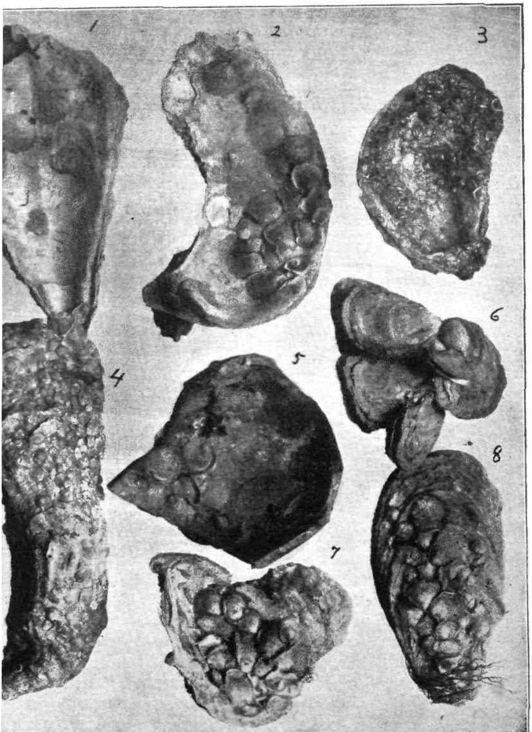


PLATE X.

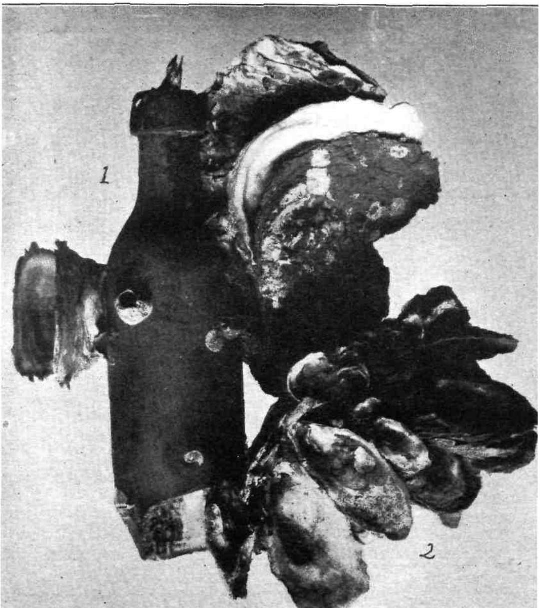


PLATE XI.

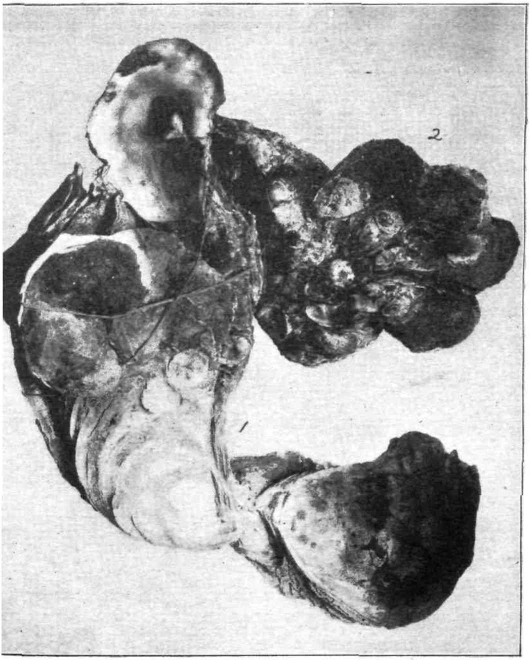


PLATE XII.

PLATE XIII.

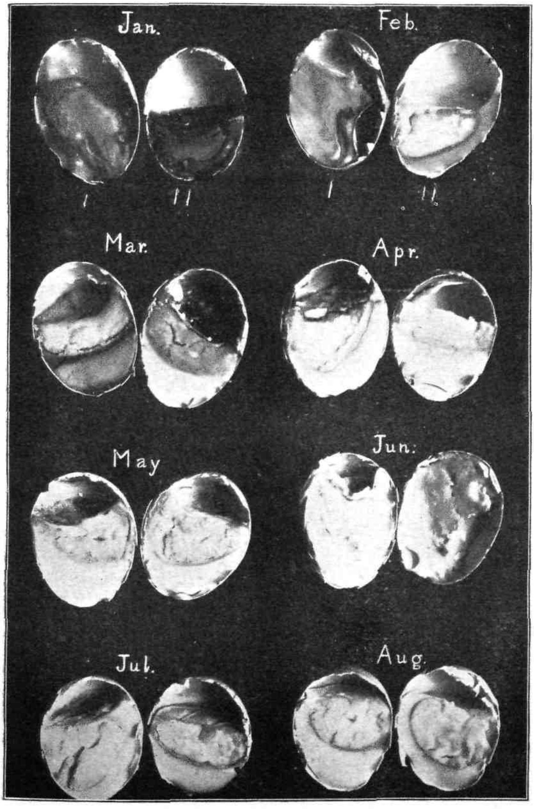


PLATE XIV.

II. Egg-Production of Virgin Fowls (*Concluded*).

Last year we gave the first report on an experiment to show what influence the presence or the absence of the male might have on the egg-production of the hens. From the tables given with that report no decided conclusion was possible. We now have the same flocks of fowls observed throughout an additional year. The following tables give the daily egg-production in each pen throughout the year. It is, of course, impossible to keep the conditions absolutely alike in the two flocks aside from the experimental variant, as is necessary in accurate work. Hence we must allow a margin, and it is evident that, allowing such margin, we must conclude that the total yearly egg-production per hen in these two flocks is practically the same. In pen I., where the male was present, each hen averaged 126 eggs during the year; in pen II., where the male was absent, the average was 118. Owing to death early in the year of one hen, which "never was any good," in pen II., we have divided the total 944 by 8. In the other pen a hen died late in the season, and account of that has been taken in making the average. If all the conditions of the competition had been perfectly fair, we would have to conclude that the presence of the "rooster" will make a hen lay eight eggs more per year than if he is absent. But owing to the necessary margin to be allowed, we must conclude that the presence or the absence of the male bird exerts no great influence on the fertility either way.

During the year the hens have been under the supervision of Mr. George A. Billings, who has kept eggs from each flock for me, taking a couple each week. These eggs have been investigated as to their deterioration or keeping qualities. They were kept in a box in the office throughout the year. A general inspection of these eggs shows that, so far as becoming rotten is concerned, they have kept very well. But they have greatly lost weight by evaporation. Those laid in January had by November lost over a third of their weight. The February eggs lost an average of 12 cc. water apiece or 40 per cent. of their bulk. The March eggs lost 22 per cent. of their volume or 10 cc. each. The April eggs lost 19 per cent. of their bulk. The May eggs lost 17 per cent. of their bulk (7 cc.) apiece. The June eggs lost 12 per cent. of their bulk. The

July eggs lost 10 per cent. of their bulk. The August eggs lost 7.5 per cent. of their bulk or 4.7 cc. each.

The loss was ascertained by floating the eggs successively in a cylindrical graduate filled with water up to a fixed mark when each egg went in. The column was read with the egg floating and again when entirely submerged. The total for the eggs of each month was averaged. It was noticed that occasionally an egg would be found that departed widely from the average, and there must be a vast difference in the rapidity of evaporation through the shell of different eggs. It is well known that the chamber of an incubator must be kept saturated with moisture to ensure a good hatch, and that eggs hatch better when the hen steals her nest on the ground than up in the hay. The moisture of the ground helps to preserve the eggs.

It is also to be noted that as the eggs lost moisture the air-chamber at the large end of the egg enlarged. The shell of a hen's egg is lined by two membranes and the air-chamber forms between the two membranes. As the white shrinks the inner membrane follows it. At the same time the pores of the shell are sometimes large enough to permit the entrance of mould spores that grow in this chamber upon the inner membrane. It was remarkable how large a percentage of these eggs had formed large air-chambers without the entrance of germs.

It must be noted that the eggs had been kept in the box in pasteboard compartments, standing with the little end down. Some of the eggs had lain on the side and the air-chamber had worked around.

There was no noticeable difference in the condition of the eggs derived from the two pens. The plate shows a photograph of one egg from each month from each pen. The eggs were hard-boiled and split lengthwise to show the amount of shrinkage. A few of the eggs had undoubtedly been invaded by germs and a gaseous fermentation was present, but only to a slight extent. The gas bubbles did not usually show up except the shell was punctured before heating to let out the expanding air from the air-chamber to prevent bursting. However, even without this precaution, only a small proportion burst during cooking.

Table Showing the Egg Production in Pen I., from November 1st, 1905, to November 1st, 1906 (Cock and Ten Hens).*

DAY.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.
1	4	5	3	3	2	7	2	5	5	4	1	1
2	5	4	5	6	4	3	1	5	4	1	2	1
3	3	5	6	5	3	6	2	5	3	5	2	2
4	4	5	5	6	3	4	6	3	3	4	2	1
5	2	3	3	4	4	6	0	3	4	2	1	1
6	4	6	5	5	3	5	2	5	4	2	1	0
7	2	4	4	5	2	3	3	3	3	4	0	0
8	4	5	5	5	3	5	0	6	3	2	2	0
9	0	4	3	5	4	5	3	5	1	4	0	0
10	4	7	4	2	3	6	2	3	6	4	0	0
11	4	4	4	6	4	3	1	5	1	5	0	0
12	4	5	5	5	4	8	3	4	2	4	1	0
13	3	4	2	5	3	4	2	4	2	3	2	0
14	5	6	4	3	3	5	3	2	2	4	2	0
15	3	7	4	7	4	5	4	5	3	3	0	0
16	4	4	4	2	4	4	5	4	1	6	4	0
17	1	9	2	7	3	5	4	5	4	3	1	0
18	4	7	4	2	4	9	3	6	2	3	2	0
19	3	4	3	5	5	4	4	4	3	1	3	0
20	4	7	4	5	2	7	5	3	2	2	3	0
21	6	4	1	2	3	5	4	3	2	2	3	0
22	5	6	2	6	5	4	7	5	2	2	3	0
23	4	4	6	4	4	2	6	5	1	2	2	1
24	6	5	5	4	1	3	6	5	4	3	4	0
25	5	5	6	2	6	2	6	4	2	2	2	1
26	4	6	3	4	7	3	3	3	5	2	1	0
27	3	3	4	4	5	1	3	6	4	3	3	0
28	5	4	5	2	3	2	4	5	1	2	2	1
29	4	5	3	4	6	1	7	4	4	1	1	1
30	6	3	4	0	6	5	6	6	5	3	1	0
31	0	5	5	0	?	0	4	0	1	2	0	0
Totals	115	155	123	125	113	132	111	131	89	90	51	10

1,245. Average per hen, 126.

* Remarks.—Only 9 hens from August 1st. Twenty-three cases of broody hens.

Table Showing Egg Production in Pen II., from November 1st, 1905, to November 1st, 1906 (Nine Hens, No Cock).*

DAY.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.
1	0	3	3	3	5	4	3	4	2	1	2	0
2	4	5	5	2	2	4	4	7	4	1	1	1
3	4	5	3	3	3	2	4	4	3	0	0	0
4	2	7	5	2	1	3	3	2	2	1	1	1
5	4	4	3	1	2	5	3	5	2	1	0	1
6	2	4	3	2	5	2	4	3	4	1	0	0
7	4	4	5	2	5	3	4	5	5	2	0	1
8	5	4	5	?	3	3	4	4	4	2	1	0
9	5	4	3	3	3	6	4	4	2	1	0	1
10	1	4	2	2	2	5	3	4	3	2	1	0
11	3	5	3	1	5	4	3	3	2	3	1	1
12	5	2	4	2	4	5	4	3	4	1	2	0
13	2	5	2	1	2	3	5	5	3	1	2	1
14	4	4	4	1	5	5	5	2	2	0	2	0
15	5	5	1	2	2	4	1	3	3	2	2	1
16	4	4	3	1	4	4	2	2	2	4	0	0
17	6	4	3	2	5	7	2	2	0	2	2	1
18	5	6	3	1	6	4	1	3	2	3	3	0
19	4	6	1	2	3	5	2	2	1	3	1	1
20	5	7	3	2	5	7	1	0	2	3	1	0
21	5	3	3	1	3	5	2	1	2	2	1	0
22	4	5	2	2	6	3	3	0	2	2	0	0
23	2	6	4	2	1	2	0	2	1	2	1	0
24	4	5	3	2	5	4	0	0	1	2	0	0
25	5	4	2	2	5	4	1	1	1	2	1	0
26	2	6	2	4	2	5	4	0	0	2	1	0
27	5	5	3	3	4	4	4	1	1	3	0	0
28	3	3	2	4	4	2	2	1	1	0	1	0
29	6	4	3	1	6	2	4	1	0	2	0	0
30	4	3	1	0	5	5	4	1	0	0	0	0
31	0	4	1	0	?	0	3	0	0	1	0	0
Totals	114	136	90	56	118	121	89	75	61	52	27	10

944. Average per hen, 118.

* Remarks.—Only 8 hens from March 15th. Twenty cases of broody hens.

III. APPLICATION OF VON BEHRING'S METHOD OF IMMUNIZING CATTLE AGAINST TUBERCULOSIS.

The outcome of Dr. Koch's studies of tuberculosis was the discovery of *tuberculin* by means of which we are enabled to diagnose the presence of tuberculosis in cattle at a very early stage of the disease. This substance is a solution of certain chemical substances, toxines among others, produced by tubercle germs, to the presence of which in small quantity cattle are rendered sensitive if they have active tuberculosis. It is not an absolute diagnostic agent for the presence of living tubercle germs in the animal organism. In certain cases this disease is temporarily latent, in which case the animal fails to respond to the administration of tuberculin. In other cases an excessive development of tuberculosis prevents the animal from noticing the slight accession of tuberculin injected; finally, the animal may become habituated to tuberculin injection so as to lose its sensitiveness. It is well known that if a tuberculin injection is to be repeated in a short time it is a wise precaution to increase the dose. Tuberculin is not a perfect diagnostic agent, and yet it is so nearly perfect that its discovery may be considered one of the great and beneficial discoveries of our day. By its use we have received a revelation, unpleasant no doubt, but salutary, of the tremendous prevalence of this dread scourge, "the great white plague," among our cattle.

Much was hoped from tuberculin as a curative agent. Dr. Koch worked long at the problem of modifying his tuberculin until it should prove a specific cure, but without success. Meanwhile our sanitarians and veterinarians turned their attention to the use of tuberculin in detecting this disease, so that the sick animals could either be destroyed or be so quarantined as not to contaminate healthy stock. It was found that the young of tuberculous mothers are born healthy, and that they become infected from the use of their mother's milk or that of other tuberculous cows.

On the strength of this knowledge, various schemes were evolved by means of which it was hoped to eradicate tuberculosis from our herds. Professor Bang, of Denmark, was the most prominent among those to advocate a plan, which was adopted by his government and which received the hearty endorsement of the dairymen

Briefly this plan was, first, to test the herds with tuberculin, next to isolate all the reacting animals, then to destroy all those that showed serious physical signs of the disease, then to thoroughly disinfect the premises occupied by both the tuberculous and the non-tuberculous herds, then to keep a rigid watch to prevent the carrying of germs from the quarantined to the non-quarantined animals. The milk of the reacting stock was to be carefully pasteurized or sterilized. Special pasteurization at 185° F. was found necessary to destroy the tubercle bacillus. The calves born of quarantined animals were immediately separated from birth, and fed milk from the sound herd or else sterilized milk. Unfortunately the use of cooked milk produced the disease called "scours" in calves, and it was seen that heating destroys certain "bodies" in milk and causes changes, making it not only less digestible but an unadaptable food.

Professor von Behring found by experiment that if raw milk received a proportion of formaldehyde equal to one part in ten thousand, such milk would not have its digestive and nutritional properties altered, while the development of its germ content would be restrained, and also that such milk would cure the scours. His idea was not received kindly—first, because the use of formaldehyde was of the nature of an adulteration, and also favored habits of uncleanliness among farmers; and second, the presence of a simply restraining antiseptic was not sufficient to kill the tubercle bacilli, so that we were really no better off than before in our fight against tuberculosis. In other words, to add a germicide to food in sufficient amount to kill the pathogenic germs is to add a sufficient amount to act injuriously upon the protoplasm of those who partake of such food.

Varying degrees of success in building up healthy herds from a tuberculous nucleus by the Bang method have been reported. But, on the other hand, there have been so large a proportion of failures that it was seen that however theoretically perfect such a method might be, it is practically too difficult to properly apply. First, it is almost an impossibility to disinfect premises that are thoroughly infected; second, it is a practical impossibility to keep germs from a quarantined herd from being carried in some way—careless attendants, flies, mice, etc., will scatter the germs; our fields are infected; the very fodder that the animals eat may

harbor the germs. Owing to the fact that some animals with latent tuberculosis fail to respond to the tuberculin test, our so-called sound herds are ever and anon exposed. Now and then an animal in a sound herd will respond to the tuberculin test, and in barns once infected it is only a question of a few years before the so-called "sound herd" will be found as badly infected as was the old one. This has been our experience, and this has been the experience of many dairymen who have tried the Bang method of combatting tuberculosis. It is an eternal fight. Every year the herd must be tested; every year a considerable proportion of the herd must be sacrificed or quarantined. It is not a successful way of eradicating tuberculosis. If to-day every reacting animal on the face of the globe were quickly burnt up, and even with disinfection of the premises, it might not be ten years before there would be as much bovine tuberculosis as at present.

This is a serious disease. It causes direct loss of stock, it interferes with nutrition and milk production; but, above all, it is a menace to human health. Professor von Behring believes that nearly every case of human consumption is due to contamination by means of milk taken in infancy, either infected human milk or infected cow's milk. Dr. Koch created a sensation a few years ago by proclaiming that the bovine germ is a different species from that found in human beings. But the researches of others have shown the error of this view, and Dr. Koch himself no longer holds it. The human and bovine germ are simply two varieties of one species, and of the two the bovine variety is the more virulent, both for cattle and for man. It is imperative, therefore, to secure a means of eradicating tuberculosis in cattle. Professor E. von Behring, fresh from his triumphs in discovering diphtheria antitoxine, turned his attention to the relation between bovine and human tuberculosis. He inoculated cattle with human tubercle bacilli and discovered that under certain conditions such inoculation rendered cattle immune to the bovine germ. Already, at the close of 1901, he had definitely proven the conditions under which such immunity could be conferred upon cattle, and in May, 1902, issued a formal publication describing his method.

Briefly, the method is as follows: A culture of human tubercle bacilli, so treated as to "mitigate" or attenuate its virulence, is dried and put up in vials containing 5, I. E. or 20, I. E. The

letters I. E. stand for "Immunisier Einheit" or "immunizing unit." A unit is the amount that is to be injected into an animal at the first inoculation. A second inoculation is to be made three months later, at which time each animal receives five times more than at the first vaçcination.

The term vaccination is applied from analogy with Jenner's discovery for conferring immunity against smallpox. In both cases it is the living germs that are introduced, and not a simple lymph or serum, or even a mass of dead germs. Hence this matêrial is a vaccine, and to distinguish it from other preparations of germs, *Bovo-vaccine*. A preparation of virulent tubercle bacilli called Tauruman has been tried, but with indifferent success.

A unit of dry bovo-vaccine weighs about four milligrams. On the day of inoculation the contents of as many vials as are needed are rubbed up by a pestle in a mortar, with sterile physiological salt solution, and the emulsion is diluted until each unit is contained in two cubic centimeters of the emulsion.

The animals eligible for vaccination should be under three or four months of age. Older animals, up to three years of age, have been used, provided they can pass a tuberculin test, but no guarantee can be given that every animal shall acquire a strong immunity if it is over three months of age. In certain cases even incipient tuberculosis has been arrested or healed by this vaccination, but such curative tendency is probable only in very young stock, hence it is not necessary to test animals under three months with tuberculin.

The animals are prepared for vaccination by having the hair clipped over the jugular vein, near the base of the neck, and the area washed with a two-per-cent. solution of irisol. The vaccine having been warmed to blood heat, is carefully shaken so that the germs are evenly distributed and the required dose (2 cc. for first, 10 cc. for second vaccination) is drawn into the syringe, which has previously been sterilized, washed with irisol solution and rinsed in the sterile salt solution. The air is expelled, and the needle is removed while the barrel of the syringe is placed in warm salt solution. The needle is thrust into the left jugular vein by the following method: On the right of the calf are two assistants who hold it. The foremost man turns the head up and to the right around his left thigh. The operator, with his left thumb,

compresses the jugular vein until the obstructed blood flow produces a swelling in front of his thumb. Into this swelling the needle is thrust, pointing forward and at an angle of 45°. When it has properly entered the vein, the blood flows from the needle. Then an assistant hands the operator the syringe, which is joined to the needle, and the contents are steadily forced into the circulation. The syringe, with needle, is rapidly withdrawn, the skin at the puncture is rubbed with the finger and anointed with irisol solution. The syringe is rinsed in sterile salt solution and the operation is repeated on the next calf.

Of course, this operation it to be conducted with the usual aseptic precautions, the vaccine must not be contaminated and no vaccine should be dropped except into irisol solution or other disinfectant, a couple of basins of which should be at hand. The vaccine is best kept during the operation in a colored glass bottle, especially if much light is present. Sterile graduates for measuring solutions are also needed.

The vaccinated animals are to be kept apart from tubercular stock until the immunization is well in progress—say a month after the second vaccination. For the first five days after each vaccination the temperature of the calves should be observed, and as much longer as will permit it to fall to 103° F., or lower. *If there are tubercular lesions present, the temperature will indicate a "reaction," as in the case of the tuberculin test.*

The germs thus thrown into the circulation are steadily but slowly "absorbed" or destroyed, hence the second vaccination is delayed ninety or a hundred days. After the second vaccination *some germs may be still unabsorbed for nearly a year, a fact indicated* by a response if such animal is tested with tuberculin. About four to six months after the second injection the immunity acquired is so strong that if a dose of virulent bovine tubercle bacilli be increased ten times above that fatal to an unvaccinated animal, and be injected into the circulation of the vaccinated animal, these germs will be destroyed and will produce no lesions nor cause the subject to become sensitive to tuberculin. This test of the immunity is sensationally performed as follows: A number of the vaccinated animals are chosen, and an equal number of "control" animals. The latter must be healthy and show no response with tuberculin. The virulent culture is injected into all the ani-

mals. The experiment has been repeated a great number of times with practically the same result. The unvaccinated animals soon develop a sensitiveness to tuberculin, followed by increasing clinical symptoms of advancing tuberculosis, and some of them may die within a month. The vaccinated animals remain perfectly healthy and do not respond to tuberculin. Necropsy on both sets of animals show no tubercular lesions in the vaccinated stock, or possibly healed lesions, if they were tubercular when vaccinated, while the non-vaccinated stock is typically and extensively invaded by tubercular lesions.

Of course, such a test is not the equivalent of a natural exposure to infection through a series of years. The oldest bovovaccinated animals are now only four years of age, so it is impossible to state whether the immunity remains undiminished throughout a long life. But from such observations as have been made, the stock has resisted infection for three years. The following are the principal of these tests:

In 1902, the Hessian government authorized a test of von Behring's method on an estate near Grünberg. Since that date, the young stock has regularly been immunized.

A hundred heifers were later vaccinated at Gören, in Mecklenburg, and another hundred head, belonging to Prince Ludwig of Bavaria, were vaccinated at Sarvar, Hungary. Dr. Strellinger, director of the vaccinations, reports in 1905 that, during three and a half years, he has vaccinated 880 cattle with satisfactory results. Interesting details of these experiments are reported in the New York *Medical Journal*, January, 1906.

Ninety head of cattle on two estates at Wolfshagen (Mecklenburg) were vaccinated. On the Marbach-Behring estate thirty calves were immunized and left with a herd of coughing cows so tuberculous that every once in a while one died. In the summer of 1904, these calves, together with as many control calves, were sent to a pasture where a tuberculous herd had grazed for three years. At the close of the season half of the control calves had developed a sensitiveness to tuberculin, but none of the vaccinated ones.

In 1904, at Melun, Professor Vallee tested the von Behring method on twenty-one calves, and acquired twenty control calves for comparison. Some of the stock was placed with tuberculous

herds and some was autopsied, and some tested with virulent germs with the usual results.

Count Schwerin-Goehren, September 5th, 1906, reported to the Agricultural Main Society of the Grand Duchy of Mecklenburg-Strelitz, that in the last three years 3,000 vaccinations had been performed under control of the society. Comparative tests with Tauruman showed the vast superiority of bovo-vaccine.

In January, 1906, Dr. Samuel Buckley, veterinarian of the Maryland Agricultural College, reported a full and satisfactory test with the bovo-vaccine. Dr. Roessler reported a test from the estate of Archduke Frederick in Austrian Silesia, saying that 700 cattle had been immunized with brilliant success.

Thos. Canfield, of Lake Park, Minnesota, had ninety-five head of cattle bovo-vaccinated in 1905, including all under three years, that did not respond to the tuberculin test. The State veterinarian recently tested thirty-five animals of this herd with tuberculin without securing a reaction.

Dr. Ebeling, in the Tieraerztliche Wochenschrift, 1905, reports that 1,126 calves had been immunized and that thirty-seven of them had been necropsied and only one showed tubercular lesions, and that reacted when vaccinated. These had all been exposed to infection in a tuberculous herd.

The *American Veterinary Review*, May, 1906, refers to experiments by the Italian Commission, whose results raised unbounded enthusiasm.

Dr. Roemer, of Marburg, states that up to January, 1906, during three and a half years, fully 70,000 head of cattle had been immunized.

At the suggestion of Dr. John V. Laddey we decided to test bovo-vaccine in our college herd in February, 1906. Seven calves under three months were found available, and from the older stock we selected two that passed the tuberculin test, so we had nine in all. The bovo-vaccine was secured through von Behring's American agents, C. Bischoff & Co., of New York City. The first vaccination was given February 24th, the operator being Dr. Wilfred Lellman, professor in New York University, assisted by Dr. Laddey. Several prominent veterinarians from this part of the State witnessed the operation. The second vaccination was given May

The calves were as follows:

1. Colantha's heifer, grade Holstein, seventeen days old. Its mother reacted to tuberculin a year before.

2. Select's heifer, grade Guernsey, twenty-one days old. Its mother passed the tuberculin test without reaction a year ago.

3. Perfection's bull calf, grade Guernsey, twenty-one days old. Its mother showed decided reaction to tuberculin a year ago.

4. Regena 5th's heifer, thoroughbred Ayrshire, thirty days old. Its mother reacted to tuberculin a year ago.

5. Cherry's heifer, thoroughbred Ayrshire, thirty-seven days old. Its mother had reacted to tuberculin.

6. Regena 4th's bull calf, thoroughbred Ayrshire, five weeks old. Its mother had reacted, had shown physical symptoms and had been quarantined in the hospital barn.

7. Mijnke 4th's bull calf, grade Holstein, six weeks old. Its mother was also in the hospital barn for tuberculosis.

8. Evesta 5th's second heifer, thoroughbred Ayrshire, five months and ten days old. Mother not tested.

9. Regena 4th's heifer, thoroughbred Ayrshire, twelve months and two weeks old. Mother tuberculous.

The temperatures of these animals after the several vaccinations were as follows:

	DATE.	1 Colantha's.	2 Select's.	3 Perfection's.	4 Regena, 5th's.	5 Cherry's.	6 Regena, 4th's.	7 *Mijnke, 4th's.*	8 Evesta.	9 Regena's yearling.
First Vaccination.	1906.									
	February 24th, 7 P. M.	102.7	102.8	104.5	102.5	102.9	103.4	103.6	102.6	101.8
	February 25th, 9 A. M.	104.9	102.4	103.7	104.0	102.1	102.4	101.9	102.9	103.0
	5 P. M.	103.8	103.9	103.8	104.5	102.8	103.2	102.9	103.4	102.1
	February 26th, 8 A. M.	101.9	102.1	103.0	102.7	102.0	102.4	101.9	102.7	101.8
	4 P. M.	102.0	102.9	102.6	102.1	102.1	102.0	101.8	102.6	102.1
	February 27th, 8 A. M.	101.4	101.5	102.8	102.4	101.3	102.4	101.4	102.7	101.8
	5 P. M.	102.5	102.9	103.0	102.5	102.6	102.0	102.9	102.4	102.1
	February 28th, 8 A. M.	102.4	103.3	103.4	102.3	102.1	101.7	101.9	102.3	101.2
	4 P. M.	101.7	102.6	102.4	102.5	102.0	102.1	....	101.9	101.7
	February 29th, 8 A. M.	101.8	101.6	102.8	102.4	102.1	101.4	102.0	101.6	101.0
	4 P. M.	101.9	101.9	102.5	102.1	102.3	101.9	101.7	102.0	101.3
Second Vaccination.	*1906.*									
	May 28th, P. M.	104.9	105.4	103.1	105.3	106.1	105.5	102.9	106.8	102.0
	May 29th, A. M.	103.4	103.7	104.0	103.2	103.8	104.3	103.5	104.1	102.4
	P. M.	102.9	103.1	104.8	102.6	102.8	105.1	103.6	102.8	101.9
	May 30th, A. M.	103.1	103.6	103.1	103.2	102.5	103.8	103.7	104.1	102.5
	P. M.	102.6	103.2	103.6	102.9	102.9	104.5	103.5	103.7	103.4
	May 31st, A. M.	102.0	102.7	101.9	102.6	102.3	102.6	103.2	101.9	102.3
	P. M.	101.8	102.3	102.4	102.4	102.2	103.7	101.8	102.4	101.6
	June 1st, A. M.	102.0	102.3	102.3	102.1	102.1	102.2	101.5	102.1	101.6
	P. M.	101.5	103.0	102.3	102.3	102.5	103.6	103.0	102.5	101.6

From these records we see that there was some disturbance of temperature, doubtless due to the presence of incipient tuberculosis in the two oldest animals at least. Nearly all, it must be remembered, had tuberculous mothers. We shall watch these animals in the future and compare their tuberculin record with that of non-vaccinated stock.

Dr. Leonard Pearson, of the University of Pennsylvania, has independently worked up a vaccine to immunize cattle against tuberculosis, which we hope to test in the future.

REPORT OF THE BOTANIST.

24 (369)

REPORT OF THE BOTANIST.

BYRON D. HALSTED, SC.D.

EARLE J. OWEN, B.S., ASSISTANT.

During the passing year the work of the Botanical Department as been chiefly that of plant improvement by breeding and se- ection among truck plants. Alphabetically, the list of subjects eceiving the most attention is: Beans, corn (sweet and pop), egg- lants, squashes and tomatoes, while, in a small way, a place has een made for martynias, okra, onions, peas, peppers, salsify and do, to which the "Prairie Huckleberry" and several strains of Chinese Cabbage" may be added as "novelties."

With beans, the work thus far accomplished gives hope for the ecuring of a stringless snap variety, with fleshy pods, bearing nall white seeds. Aside from the above desirable qualities, a igh degree of productiveness is sought for rather than extreme arliness. The number of crosses already secured is large and, ith some of them, the fifth generation is past and a fair degree f fixity secured. By means of the greenhouse, a generation is ained, and with the midsummer planting three crops are secured ı a year. Among the lima beans many crosses have been made at may help in bringing this highly-prized vegetable more nearly perfection. On account of the prevalence of the mildew, which favored by the surrounding dense, often moist, foliage, efforts re being made to secure desirable types of seeds that are asso- ated with the "willow-leaf" form of foliage and, also, more ngth of flowering stem that the pods may be formed in the open oove the leaves. The hybrids of the bush beans and "Scarlet unner" have been grown another year, and some of the offspring ıow decided productiveness with the dwarf nature and may de-

velop into a strain of beans of much value. These hybrids are likewise not without interest from the standpoint of the breeder, as the work gives an insight into the natures of the subjects and the possibilities that may be hoped for along other lines of breeding.

As large a number (twenty-five) of blocks of cross-bred sweet corn as possible have been grown upon the three acres included in the Gardens in addition to which as many more throughout the State through the co-operation of growers of truck crops. Perhaps the results that are most deserving of notice are the "Malamo" and "Malakosby" varieties, seeds of which are to be offered under their respective names the coming spring. They both have the "Malakhov" as the male parent, from which great speed with no apparent loss of desirable qualities is secured. Both sorts have been extensively tested throughout the State during the past season, and upon the Home Grounds they were closely studied and gave satisfactory results. A large number of other crosses are adding a generation to their history, and the notes show that some are meritorious and deserve further attention. A greater length of grain in medium-season, main crop varieties is sought for by breeding the "Country Gentlemen" and "Stowell's," for example, with early sorts. The effect of breeding pop and field with sweet corns is being studied and, also, the correlations of special colors in tassel, silk, cob, husk, etc., to desired qualities of plant and its product.

The year's work in breeding eggplants has brought some results of immediate value to the truckers in a desirable new strain, having a long, bell-shaped fruit that is pink upon the exterior and of a very pleasing white within, the flesh suggesting that of the "Snow" apple. A white-fruited kind has also been secured that, when grown in sufficient quantity, may be offered as the "Ivory" eggplant. From a scientific standpoint, some results have been obtained in the hybridizing of the "American" and "Chinese" species that, it is hoped, may throw light upon the question of dwarfage and fruitfulness, not to exclude spinoseness in eggplants.

The work with squashes is along two lines, namely, the summer varieties and the winter sorts. One of the attempts with the first is to get a specially early and prolific variety and some promise is met with here. Another problem is to add to the present types another that is neither flat ("pattypan") nor long "crook-necked,"

but broad-fruited with a short, straight neck which, for lack of a better name, has been temporarily dubbed the "jug." It is to be free from warts and of a white, cream or orange, as may be desired. It has been found that fruits secured by breeding within the crossed plant give offspring that are sufficiently close to the mother type to inspire hope that almost any form in a summer squash may be secured. The ease with which the surface irregularities (warts, etc.) may be eliminated is likewise interesting if not surprising. With the vine squashes there is a large field for improvement and one with many inherent difficulties, but with a suitable rich soil—nowhere more important than here—and plenty of it, one need not be discouraged. During the present season several crosses were developed, some of which show much of promise. The combination of the "American" and "Japanese" has given fruits that, while in themselves are unimportant, may be a step toward desirable combinations. In the same way other hybrids obtained between American species may bring direct good after much further breeding.

With tomatoes the lines of work are being centered somewhat upon a longer fruit of the large type, not the "pear," drawn out and enlarged, but a "goose egg" with the interior filled with flesh having many very small seed cavities. In this quest the lack of an ideal tomato of the ordinary type is not overlooked, and, out of the hundreds of combinations thus far made, there are several of especial merit—one of which, the "Marvelosa," ("Marvel" upon "Ponderosa") will be added to the list of those already developed and seeds distributed next spring. It has borne the test well during the past season.

On the secondary list of vegetables under consideration the peas show much to warrant special attention. Some of the crosses, made in the hope of getting a small, early sort adapted to the needs of the canners, are showing merit, and it is hoped, with two crops in a year, to develop a desirable sort with comparative rapidity.

During the year two bulletins, namely, No. 191, "Seed Distribution of 1904 and for 1905," and No. 192, "Breeding Sweet Corn—Co-operative Tests," have been issued by the department, the last one of which deals with certain laws of breeding deter-

mined with corn that may prove to be widely applicable to other vegetable fruits.

The seed distribution of last spring embraced 1,332 packets, as follows: Lima beans, 112; sweet corn, 329; eggplants, 267; squashes, 216, and tomatoes, 408 packets, respectively.

A branch for seed inspection has been opened and the offer is made to examine samples of clover and allied seeds as to their purity.

During the year a two-story addition has been built at the Gardens that furnishes an office and tool-room upon the first floor and space above for the many requirements in maintaining and harvesting the several crops.

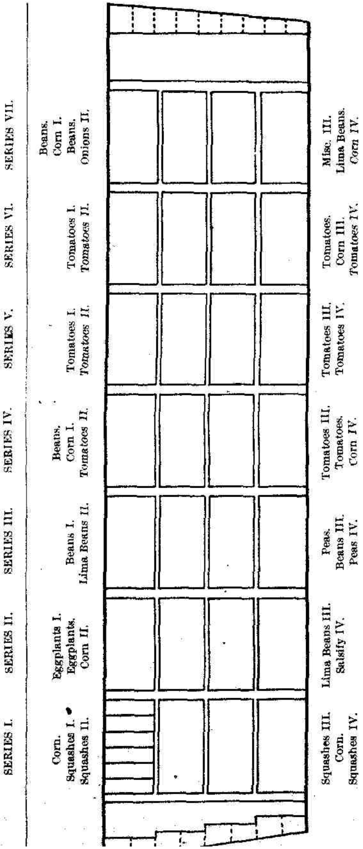
THE EXPERIMENT AREA OR GARDEN.

The plan of the Garden proper is given upon the opposite page and consists of two acres, divided into seven series with four plots to each. Paths separate the series and others running lengthwise of the grounds complete the approach to all sides of each plot. There is an irregular block of ground at each end of the rectangular plots, as shown in the plan, and these are occupied with ornamental plants and grass experiments.

The soil is fairly uniform in quality, it being a mixture of clay and gravel, and at the outset was not of the best for garden purposes, *but its texture has been much improved by the annual application* of manure at the rate of twenty tons per acre for the past twelve years.

In addition to the above area, one acre, in three long and widely-separated strips in an adjoining field, has been used for the past two years. Upon this "new land" several of the corn-breeding plots were located, and, between them, crossed beans and squashes have been grown. The soil of this recent addition to the College Farm is far from satisfactory for the best work in breeding where a rich deep soil is a prime requisite, but it may be improved from

The Experiment Area for 1906.



EXPERIMENTS WITH SWEET CORN.

Fourteen blocks of cross-bred sweet corn were grown upon the two acres of the Garden proper, care being taken to plant alongside of each other the early and late-blooming crosses in such a manner as to prevent inter-breeding. The earliest kinds were planted first and near opposite ends of the Garden.

"Malakhov-Premo"—"Malamo."

A block of forty-two (6 by 7) hills of "Malamo" sweet corn was planted in series II. upon April 25th, and a second patch of forty (5 by 8) hills upon April 30th. The weather conditions for early growth were so unfavorable that these two lots of corn appeared the same in all respects throughout the season and are treated as one. The results here and elsewhere lead to the opinion that the growth period of sweet corn depends largely upon the time when the seed is planted. In other words, corn planted upon May 15th will yield table ears in much shorter time than when planted three weeks earlier. In this particular case, one block gave table ears in seventy-six and the other in seventy-one days, and, had there been a third and later planting, the time probably would have been still more shortened.

The tagging of the stalks began with the first appearance of the tip of the tassel upon June 20th and closed upon July 2d, a period of bloom of nearly two weeks. The tassels, usually tinged with pink, were occasionally green, and the silk (which came two or three days later than the tassel) varied from red through pink to green. The green tassel was associated with green silk, that is, the color when present showed itself throughout the plant, the stalk being sometimes tinged with purple. The "Premo" parent shows similar range of color in the plants.

The stalks varied somewhat in size, there being a few of the small, slender type of the "Malakhov," and these, usually among the first to bloom, were regarded as undesirable and at once discarded. The majority of the plants averaged five feet and some reached the height of six feet. A set of measurements was taken upon the growth of stalks, after the tassel showed its tip, with the

DATE.	HEIGHT.	DATE.	HEIGHT.
June 22	3 ft. 6 in.	June 28	5 ft. 1 in.
" 23	4 " 0 "	" 29	5 " 2 "
" 24	4 " 5 "	" 30	5 " 3 "
" 25	4 " 8 "	July 1	5 " 3½ "
" 26	4 " 10 "	" 2	5 " 4 "
" 27	5 " 0 "		

At the first hoeing all suckers were removed from the plants in alternate rows and this desuckering was continued through the season. Upon the other rows the suckers were detasseled as they neared blooming.

A block of corn that seems short as the tassels appear will grow up to a good height in the next two weeks, during which time the blossoms have come and the ear been impregnated. The corn was studied daily and certain plants were marked with a white tag. Those showing the most vigor, indicated by size of stalk and leaves, and having one or more acceptable ears set well up from the ground, were marked and the tassel removed to prevent inbreeding. Notes were made upon the tag of the earliness, color of silk and any special point that might be of value when the final selection of seed was made.

Upon August 1st the mature plants, having lost all the green color, were pulled up and laid in a row from which the stalks with two good ears were selected. From this lot the stalks with the pairs of ears nearly of the same size, and borne well up from the ground, without suckers, were laid aside. After the ears were husked from these, the pairs of best shape—cylindrical and well filled out at the ends—with more than eight rows of fine grains, were selected.

A set of forty-three ears of the "Malamo" sweet corn is shown at 1 in Plate I. The ears are somewhat taper-pointed and vary in rows of grains from eight to twelve. Those shown upon the drying pole* are chiefly more than eight-rowed and will furnish the seed

* The dryer consists of a fence picket through which nails are driven at regular intervals upon the four sides. By bending the nail tips upward, the ears may be securely held in place by pushing the butt ends down upon the nails, as clearly shown in the engraving. These holders, when fitted with a hook at the upper end, may be suspended quite close to each other in an airy room and provide the conditions for a satisfactory curing of each ear, free from

for the first portion of the distribution. The grains are of a desirable length and the various qualities of this sweet corn are given below in the language of those who have made a practical test of it during the year.

Reports from Testers of the "Malamo."

There were seventy-six packets of the "Malamo" distributed to those requesting it, and the following quotations separate the remarks in various individual reports: "Corn was fine; ears of nice length and corn sweet and fine flavor." "Corn was fine; so sweet, we think, we never had better corn, so early in eighty days it was fit to be used. The ears were a nice size, the grains were fine all the way out to the end of the ear." "Planted corn in choice ground with Mapes fertilizer and gave it a fair chance and good attention and was given fine table ears in seventy-two days. I will say it is the earliest and sweetest corn I ever raised from any seed I have ever had sent me from any Agricultural Experiment Station. I am sure yours takes the lead." "Corn was well matured and of fine flavor. Pronounced by epicures to be the best earliest variety known." "Has proved an elegant early variety." "Corn in fine condition, four feet to five and a half feet high, just silking out." "Is very promising, stands hot dry weather unusually well; very even in size, height and appearance." "Looks healthy and vigorous." "Have fine table ears, two ears to the stalk. It is the most satisfactory small corn I have found." "Find corn very nice, tender and very sweet. Growth not large, but ears quite large and abundant. Hens seem to prefer it to all other kinds." "Corn is early and sweet." "Abundance of ears for table use in sixty-five days from planting." "Practically every stalk has two good ears, some more. We consider the quality very fine." "A valuable variety." "As forward as any corn we have." "Corn was very fine sixty-seven days from time of planting." "Has given entire satisfaction; grew in much less time than we were expecting." "A very fine table corn and a great yielder; average yield two and a quarter ears to stalk." "Ears forming forty-two days after planting." "I consider it one of the best extra early sorts." "Is an improvement on the 'Malakhov,' being larger both in stalk and ear and but a few days later in maturing." "'Malakhov-Premo' gave me table ears in sixty-nine days and it looks like

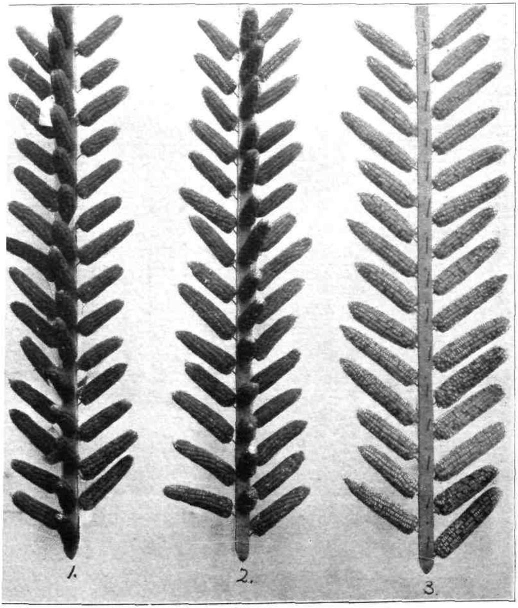


PLATE I.

Crosses of Sweet Corn. The "Malamo" is shown upon the first holder (1); the "Malakosby" at 2, and the "Adams-Crosby" at 3.

a very promising variety for early; two to three ears to a stalk and good eating quality." "It is fine, two ears to a stalk and a rank grower. It is the earliest sweet corn I have ever had." "It is the earliest I have had and the nicest." "The corn is a good cropper as each stalk has two ears." "I planted the 'Malakhov-Premo' corn on the 21st of April and had corn ready for the table on the 4th of July. Am much pleased with it." "Corn has already been tested by my family, only sixty-eight days planted and eaten. I think very much of it." "Should prove a useful early commercial table corn." "Is earlier than any variety we ever planted." "Ears were well filled." "Appears very productive." "Every grain sprouted and grew rapidly; it is a sweet and desirable early corn." "Has done nicely and given good satisfaction. Stalks small but mostly give two fair-sized ears, well formed and filled out with kernels to the point. Quality good." "It is fine—two ears to a stalk and a rank grower. It is the earliest sweet corn I have ever had and I have tried several kinds." "Good-sized stalks, seven feet high and fair-sized ears, seven inches long with eight to twelve rows of kernels. Good quality. 'Malakhov' (pure) is, undoubtedly, the earliest sweet corn but too small for market. 'Malamo' is nearly as early (within four or five days) and all right to sell."

"Malakhov-Crosby"—"Malakosby."

The fifty hills of the cross of "Malakhov" upon "Crosby" were planted May 15th. The stand was very satisfactory and the plants were stout-stemmed, bearing green broad leaves and giving an appearance, before the tassels came, quite different from the "Malamo." Suckers developed in nearly every hill and were removed from a half of the plants in alternate rows. This removal changed the appearance of the hills and the two rows, from which the suckers were removed, were somewhat earlier in maturing their ears. The suckers that were permitted to remain were all detasseled as they approached the time of blooming, so as to prevent any fertilization from these earless stalks.

The ears upon this variety were set low upon the stalks, and, when forming, were with long, slender, leafy tips supplementing the tendency to excess of foliage elsewhere. Upon July 23d, fine

large ears were gathered for the table, sixty-nine days from the time of planting. The crop began to ripen upon September 4th, when the earliest ears were gathered for seed. From the holder at 2, in Plate I., the general character of the ears of this cross may be gained. They are somewhat larger than those of the "Malamo," shown at 1, and are more uniformly twelve-rowed. There were many twins and these will furnish seed for a special experiment in selecting for large yield.

Reports from Testers of the "Malakosby."

Seventeen packets of this cross were distributed last spring, and from the reports the following remarks are extracted: " 'Malakhov-Crosby' corn did well for me; I planted it close in good soil and almost every stalk produced one or more good ears. Quality very good. Stalks from four and a half feet to six feet high and an inch to an inch and a quarter in diameter. It was well developed and fit for eating before other varieties." "The ear is of good size and quality of corn good." "The ears were about six inches long with twelve rows of pure white grains, which were as sweet as any corn I have ever eaten." "The quality being very good, we are very much pleased with it; the season here has not been the most favorable for corn." "It is very early; in sixty days was large enough to pull." "As far as our experience goes, it is a distinct variety, such as some seedsmen would take pages to describe. We planted part of the seed about May 5th, the rest ten days later. The first was ripe about July 16th, came so quickly we pulled none until the 20th, when it was a little too old to be at its best for the table. Have had two neighbors sample a few ears, and they both, and ourselves, pronounce it very good-flavored and sweet. Height of plant five and a half to six feet to top of tassel. Ears two to a stalk, borne very low down, some only six to eight inches from the ground. Ears long for size of stalk, grains large and regularly placed and ear makes a good appearance when cooked; very desirable for the home garden." "I planted April 20th the seed received from you and had fully-matured corn for the table on July 4th, seventy-five days from time of planting. Would have done very well for eating, I think, a couple of days sooner.

The ears, some of them, were well developed and good size. Got one ear seven inches long and as well developed as anyone could wish for. I showed it to several and they were all greatly surprised. I think it a grand acquisition to the list of early corns." "The 'Malakhov-Crosby' corn was planted May 4th, was fit for the table July 14th. Plant is medium size, very thrifty grower, does not sucker as badly as 'Crosby' nor smut like 'Malakhov.' Ears nice size and very symmetrical, averaging two on a stalk. Quality all that could be desired. For home or market, it is the best early corn I ever grew." "I have to report most satisfactory results from 'Malakhov-Crosby' sweet corn. Corn is excellent indeed and of fine flavor. I planted on the 12th of May, had it on table on July 10th; fifty-nine days gave me fine, mature corn for table use. Am delighted with results." "The corn is all right, the stalks grew about four feet high, the ears about seven inches, the quality sweet and fine. Fit for table in seventy-two days."

The "Adams-Crosby" Cross.

A block of thirty hills of a cross of "Adams" upon "Crosby" was planted April 25th and produced a fine stand of stout stalks, bearing heavy foliage and but few suckers, the latter being removed while young from half the hills. Upon July 12th it was noted that the stalks averaged seven feet in height and the block was one of great vigor. The tassels varied from purple to pink and some of the silks were green but mostly purple. There were *frequently two ears to a stalk and these were borne three feet or* more from the ground. Upon July 24th, ninety days after planting, ears were used for the table and were of fine size and fair quality. Maturing began upon September 4th and an early picking was made for the sake of planting to increase the earliness by selection.

The appearance of the ears of this cross is well shown at 3 in Plate I. In size this cross produces a much larger ear than the other two crosses shown in the engraving, and is a broad, cylindrical form with the oval end generally closely filled with good grains. The rows are usually twelve and the kernels rather broad.

As expected, this first generation after the blend shows at maturity that the grains are three-fourths of the starchy type and

one-fourth sweet and wrinkled. The difference is so marked that it is shown in the various ears as seen in the plate. A student counted the shelled grains from ten average ears, with the result that 3,267 were flint and 1,103 wrinkled, thus giving 74.8 per cent. of flints, or within two-tenths of a per cent. of the theoretical amount. The range of percentages among the ears was from 68.4 to 78.1. The flint and wrinkled grains (4,370) of the above ten ears were very thoroughly mixed together and divided into ten practically equal lots. These, when separated into the two types, showed a range of from 70.0 to 78.8. In other words, the mixing in nature approximated that done intentionally by man. According to theory, the sweet grains (when planted in isolation) will produce ears with the grains all sweet, and, therefore, it is intended thus to plant a block upon the Home Grounds and offer packets for testing to those who may be pleased to grow it. It is hoped to get, in this way, a sweet corn with much of the vigor of the "Adams" combined with the fine qualities of the "Crosby."

THE "MEXICAN-GENTLEMAN" CROSSES.

The crosses here considered were made in 1903, have been grown for the last three years, and a record for each successive season has been given in previous reports.

Of the cross of "Country Gentleman" upon "Black Mexican" (19/99) the grains selected for the last season were from straight-rowed ears and they made an even block of plants, above the average in height, bearing the medium-sized ears high from the ground. The yield was not large but the quality was fine. At harvest time thirty-six good ears were secured, thirty-one of which were straight-rowed and only five partially zigzag, the irregularly placed grains being in the upper half of the ear. The ears were all solid white, so that, in this case, the dark "blood" of the cross probably is not present.

The reciprocal of the above, namely, the "Mexican" upon the "Country Gentleman" (99/19), also three years from the cross was likewise grown in a block of thirty hills and produced plants of the same type. White grains only were planted and the crop was entirely free from dark grains. The ears were medium-sized and borne high upon the stalks, and of the twenty-six, gathered

upon September 8th, eleven were entirely straight-rowed and fifteen showed the zigzag type in a greater or less degree.

Two blocks of corn, above noted, were so much alike in all details that they might have been easily considered as from grains of the same uniform packet of seed.

Below are given some of the remarks made in the reports of those who tested the above crosses throughout the State.

"Mexican-Gentleman" (Solid Black Grains).

From this lot of seed twenty-five packets of kernels were distributed to those requesting the same, and from the reports the following remarks are extracted: "Stalk and ears rather short, vigor fairly good, productiveness as good as any." "Very good size and very good quality and produced a good many ears of nice even grains with all black color when ripe." "Will say that it is all that it is claimed to be, an early, sweet, tender corn. Vigorous grower, grains uniform, an excellent bearer and I would think it an excellent, early corn for market, a very thrifty grower." "Was planted early, made a rank growth to about five feet and eared about an average of two ears to stalk; ears were well filled, not very large but best shape of any early corn I had and very free from worms." "My crop averaged four feet and six inches in height; two full-grown ears to a stalk, some ears entirely dark, others mixed, very sweet, good for home use." "Did finely, plants of medium height, all bearing two, some three, large ears, quality delicious." "Grew remarkably well, bore nice, plump ears well ﬁlled out, matured very early. A good, early productive variety, ains uniform and compact."

"Mexican-Gentleman" (White Zigzag Grains).

Sixty-four testers received the above corn and reported as fol- ws: "Every stalk produced about two good ears, the grains were l *uniform in size and a very sweet flavor, ears good size,* stalks ere hearty and averaged about five feet high and ripened very enly." "Small, tender kernel, stalks eight feet high, vigorous, ghty-seven ears to about a dozen hills." "Plants made an un-

usually stocky and quick growth from the very start, of an elegant dark green color and nearly every one bore two full-sized ears averaging almost nine inches in length, thoroughly filled to the very tip with deep, even-sized grains throughout and possessing a superior sweetness not found in any other white sweet corn; would consider it very valuable." "This developed the best stalk and ear of any variety sent me for trial. A very fine quality." "Vigorous and productive." "Green corn very similar to 'Country Gentleman' but of stronger growth and more productive, ears a trifle larger, quality good." "It was very good size and yielded well." "Very good." "Very vigorous and productive and a large stalk." "It is a very promising variety." "It was unusually productive, much more so than corn I planted last year." "Found it a very sweet corn, grains very deep set and very compact, a most excellent bearer and thrifty grower, ready for the table early and would think it an excellent corn for truckers." "Is very good." "Very vigorous and productive, quality the best of any raised this year." "Quite productive." "I regard my test as a great success; it was very productive, ears were large for sweet corn, grains very fine and the general uniformity of the ears was all that could be desired in a sweet corn." "Corn was excellent, length of ears eight and a half and nine inches, diameter six inches. As productive as good corn usually is." "Plants grew five and a half to six and a half feet tall, well covered with leaves, generally two ears to the stalk, grains were very white and sweet. Grains were long and remained in an edible condition for a long time." "This would make a fair variety for early field culture."

"Mexican-Gentleman" (White Straight-rowed Grains).

This strain of the cross was sent to fifty-six persons who selected it and reported as follows: "Corn was of excellent quality." "Very sweet and good flavor." "Quality good and sweet, grains white in green state." "Tall plants, very vigorous, good flavor, I think a very good variety." "Good grower and one to two ears on every stalk, very large cob." "Good growth. I think with another year's selection you will get all ears perfect. Good quality." "Vigorous and productive, color good and satisfactory grains and ears; am well pleased." "Seed has produced a very

fine crop of ears; I find the variety a productive one on our soil, ears well filled with good-sized kernels, very sweet and prolific, a *very profitable one for the market gardens to grow.*" "Ears of this corn came up well. Some of the straight-rowed had very large kernels and were very tender." "Would say I found it an excellent early corn, several days earlier than other kinds and very sweet and tender, an excellent good grower and also a good bearer." "Strong and vigorous, two or three ears on each stalk, ears about eight inches long, flavor good." "Would consider it a very good variety."

OTHER "BLACK MEXICAN" CROSSES UPON HOME GROUNDS.

The following is a list of the crosses of the "Black Mexican" upon other varieties of sweet corn that were grown in the Garden during the past year, namely: "Banana" (6), "Gold Coin Evergreen" (26), "Striped Evergreen" (27), "Metropolitan" (56), "Perry's Hybrid" (66), "Potter's Excelsior" (69), "Quincy Market" (74), "Triumph" (88), "Garwood" (94) and "Malakhov" (95). This was the second generation, and, in all instances, grains appearing to be pure white were selected for planting the hills (usually thirty to forty-five) devoted to each cross.

"Mexican-Banana" (99/6).—This block, planted upon May 14th, made an evenly tall and slender set of stalks with large tassels, with pink anthers followed by silks that varied somewhat in their pink color. The small ears, borne high upon the stalk, were of high quality. Of the sixty-two ears harvested upon September 5th, some contained a majority of dark grains, suggesting that the mother kernels for these, although white to the eye when the seed corn was selected, probably contained dark "blood." The fact that all the other fifty-five ears contained a small percentage of dark grains is probably due to the pollen from the seven plants that bore the dark ears above mentioned. Thirty-three ears were straight-rowed, nine with the grains zigzag, and twenty showed a combination of the two types of grain arrangement. There is a suggestion here of the straight-rowed being dominant over the zigzag type.

"Mexican-Gold Coin Evergreen" (99/26).—This block was purposely not planted until June 26th, that it might escape mixing

with its near corn neighbor, an earlier maturing cross planted seventeen days earlier. The plants were large and stout, bearing green tassels and silks, followed by large, broad ears borne high upon the stalks. The cross retained much of the "Evergreen" type throughout and the grains had nearly the length of those of "Stowell's," and there is hope that this will make an acceptable mid-season variety. One ear had a preponderance of dark grains, suggesting that the attempt to eliminate the "black blood" failed in one instance, and, as a result, all the ears showed a small percentage of dark grains.

"Mexican-Striped Evergreen" (99/27).—This is a peculiar cross because the "Evergreen" has a color character that is deeper-seated than the grain, that is, the ears vary in the amount of red markings and are units in this respect. Sometimes an ear is solid red, including the cob, while another is of the ordinary white type, while others have all the grains alike, striped. The block of forty-five hills, grown the present season, was from white grains of the cross and from an ear with a white cob. Of the fifty-eight ears harvested, four were with a majority of the grains black, showing that the seeds planted carried the dark blood of the "Mexican;" one ear was solid red and one with all its grains striped. It is interesting to note that two grains, neither of them showing any of the red color, developed plants, one of which produced a solid red ear and the other one that combined the red and white to make the genuine striped type. It was also observed that two ears were with their grains manifestly zigzag. It is, of course, possible that this may have resulted from a mixing with the previous season with some of the zigzag sorts.

"Mexican-Metropolitan" (99/56).—This was a block purposely planted late, but reaching maturity and making a large growth of stalks and ears of a desirable type, usually twelve-rowed, and grains of fair length. There was a small percentage of dark grains, owing to the presence of a kernel in the seed that evidently was not pure white.

"Mexican-Perry's Hybrid" (99/66).—Here, again, the planting was late (June 26th), but the long season permitted the crop to mature. Of the thirty ears gathered for seed September 12th, one showed that there was dark blood in the grain planted and all the others showed some black kernels. The ears are of fair size and of handsome shape, being twelve-rowed, with the grains of good depth. One ear had pinkish kernels and cob.

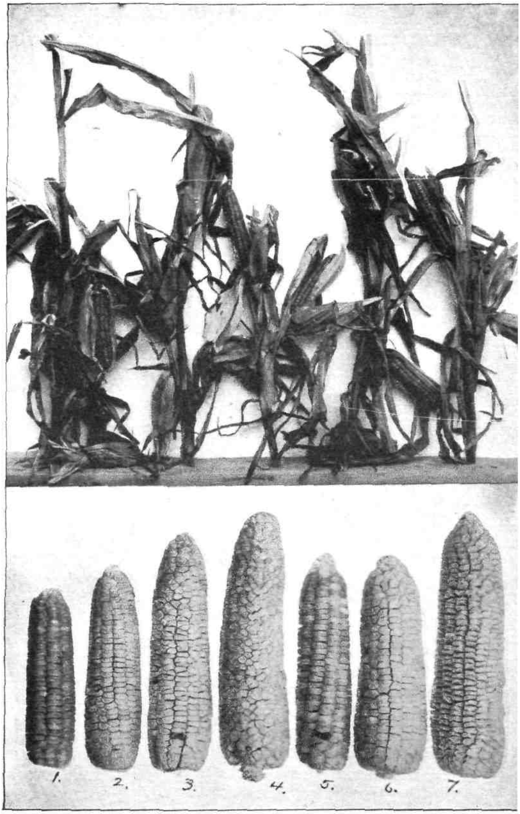


PLATE II.

Crosses of Sweet Corn. The central portions of stalks with ears of the "Mexican-Quinc Market" are shown in the upper part. Below are sample ears of the "Bantam-Gentleman

"Mexican-Potter's Excelsior" (99/69).—The block of ground given to this cross was of the poorest upon the New Land, and being planted late (June 26th) the results were meagre.

"Mexican-Quincy Market" (99/74).—This cross was planted June 9th and made a block easily recognized by its abundant suckers, and later, because of the strong tendency to form twin and triplet ears. A photograph of the fruit-bearing portion of five of the stalks was taken and are shown in the upper part of Plate II. The ears are long, slender and usually eight-rowed. A test of the table quality was overlooked until the ears were too mature. At harvest time seventy-seven good ears were gathered, seventy-one of which had white and six pink cobs. There were six plants that showed, by their much-mixed ears, that the parent grains bore dark "blood," and this caused a general slight mixing of the whole crop.

"Mexican-Triumph" (99/88).—This cross was planted late (June 26th), upon poor soil, and only seventeen good-sized ears were secured, all eight-rowed. Four showed a half or more of dark grains and one of them was quite flat, with the two belts of four rows each separated from each other.

"Mexican-Garwood" (99/94).—There were thirty hills of this cross planted late (June 26th) to escape mixing with the "Mexican-Malakhov" cross grown near by. The crop was ripe October 8th and before any frost had come. The harvest was a good one and the quality superior. Nineteen of the fifty-nine of the best ears that were harvested showed a large percentage of dark grains and forty had only a few dark kernels. While all visible precautions were taken to select pure white grains for planting, it seems evident that practically one-third of them carried dark "blood." Of these nineteen that were with half and more of dark grains eight were with eight rows of kernels like the "Mexican" type, while of the forty which were from pure white "blood," but crossed upon by the dark pollen of neighboring plants the present season, there were only eight ears of the "Mexican" type. In other words, there was a larger percentage of the "Garwood" type among the white ears than among the ears that were evidently from mixed seed.

"Mexican-Malakhov" (99/95).—This block was planted May 14th and made a fine stand of medium-sized plants, which bore straw-colored tassels and green silks, occasionally tinged with

pink. The time when ears were taken for testing upon the table was not recorded, but the first ripe ears for seed were gathered August 13th—that is, ninety-one days after planting. The final harvest was made September 28th, when sixty ears were secured, ten of which were with a majority of the grains dark and all were somewhat mixed. The plants and their ears indicate that much selection is needed to develop a sort that will be uniform in the desired qualities. There is a tendency toward flintiness in some of the grains that needs to be especially considered.

"GOLDEN BANTAM" CROSSES OF SWEET CORN.

The "Golden Bantam" (34), as might be inferred from the name, is a small variety with yellow grains, usually borne in eight rows, and has the considerable merit of maturing quite quickly. On account of its unusual color, it marks itself upon any white variety. This sort was employed as a breeder upon a long list of the leading commercial sorts in 1905, and from the crosses then secured seed was saved, from which the following results have been obtained:

"Golden Bantam-Essex Early" (34/29).—A block of forty-five hills of the "Golden Bantam" upon "Essex Early" was grown upon the New Land, and proved to be very early and gave a fair crop of well-shaped ears, five samples of which are shown in the upper left-hand corner of Plate III.*

The "Essex Early" is a white corn, the ears of which are usually more than eight-rowed. The cross, as grown for its first generation the present season, gives a neat, shapely ear, of sufficient size, with ten or twelve rows and of a quality to warrant its further growth and selection. From the engraving, it may be seen indistinctly that the ears have a mixture of "white" and "yellow" grains, the latter making up three-fourths of the total number, as might be expected from the Mendelian law, the yellow in the crossed grains showing to the exclusion of the white character present. In short, in each ear there are one-quarter of pure white and one-quarter pure yellow, and one-half that are half yellow and white, these latter showing as yellow.

* This set of ears is upon a larger scale than the other three sets in the engraving.

By selecting the white grains and planting them in isolation—that is, out of reach of other corns—the white strain of the above cross would be at once established. Upon the other hand, the yellow grains, planted by themselves, would have a total of one-third of its blood of the white strain obscured by the yellow, and, in the next crop, would come to light to the extent of one grain in nine, or 11.12 per cent. of the whole.

By growing the yellow grains of the first crop from the cross in pairs far from any other corn (to prevent the weakness that would come from growing a single isolated plant), one might chance to get a pair of pure yellow plants which, when thus bred together, would give at once solid, yellow ears, free from the admixture of the white "blood."

"Golden Bantam-Premier" (34/70).—This cross is similar to the last mentioned, but with the plants stronger, of greater vigor and decidedly more productiveness. There are several points of difference which come to the surface as the crosses are watched from week to week. In the present case, the suckers were abundant and the tassels straw-colored and the silk pink or pinkish (not green), quite the opposite of the "Bantam-Essex" cross, where the tassels were red or reddish, and the silks usually green. The point that commends the "Bantam-Premier" cross is its large number of twin ears, two of which are shown in the plate near the upper right-hand corner (1 and 2) of the engraving. They are necessarily smaller than ears borne singly, a sample of which is shown upon the right (3), and closely approach the desired type for a twelve-rowed ear. The block of forty-five hills has yielded liberally and this seed is offered for testing, both of the white and the yellow grains, distributed separately.

"Golden Bantam-Banana" (34/6).—This cross is between two widely differing varieties, the "Banana" being one of the "zigzag-shoepeg" kinds (perhaps most familiarly known by the "Country Gentleman"), and from the time the plants were knee-high a great range of variation was apparent. As the weeks passed, certain stalks, still small, flowered, and the ears were well under way before other stalks in the same hill were in bloom. A count showed fifty-eight of the small early stalks and eighty of the tall later sort. The small stalks produced an early crop of ears, a sample of which is shown at 1 in the group of five ears in the lower left-hand corner of Plate III. The greater number of stalks that matured later

produced much larger ears, that, at the same time, exhibited a remarkable variety of forms. Room for only four of these was found in the engraving. The contrast, for example, between the ears at 2 and 5 is indeed striking, but not unexpected, for the former adheres closely to the "Bantam" type, while the other is that of the "Banana," with its long, angular grains, irregularly disposed. An ear like the one at 4 is of unusually fine form and size, and may be considered a blend of the two parental types, and the one at 3 is similar, but much smaller, and possibly less desirable, unless two were generally produced upon the same plant.

"*Golden Bantam-Ruby*" (34/76).—The "Ruby" differs from the ordinary varieties of corn in having the plants purple generally throughout, with the exception of the grains and the leaves; in the latter, however, the midrib is purple, and the expansion from it somewhat of the same color. In the husks and cobs the purple is quite intense, as also in the tassel and silk. It is seen that the plants, as a whole, have an unusual color character aside from the grains. In the latter there are interesting variations, some ears having the kernels of the ordinary white kind, while others show the discoloration of the purple in certain localities, and reminding one of the similar shade of red that is found in the "blood" orange.

As grown for the past three years, the "Ruby" has shown itself to be a tall, stout-stemmed, late sort, with large, well-shaped, usually twelve-rowed ears, and grains broad and fairly deep. A cross with a smaller and earlier variety, as the "Golden Bantam," is seen to be justifiable, and the peculiarities above noted add not a little to the interest one might take in such a combination. From an early stage the crossed plants showed much variability, some of them coming into bloom while others were pushing on to nearly the double height of their neighbors. By the middle of July, it was observed that some stalks were green while others showed the purple color, and, later on, the former produced straw-colored or pinkish tassels and silks while the main portion of the thirty hills showed conspicuous purple tassels and silks. A count was made of the plants and ninety-six were of the purple type, some of them showing this color even in the blade of the leaf, while but eighteen were of the green type. It was found that the size of the plant above considered was not associated with either color type. If the purple is a dominant character of the Mendelian order, theo-

tically, there should have been twenty-eight green plants, or ten ore than actually present. However, the number of instances too small for any generalization for this crop.

Fifty-nine fine ears were harvested, samples of which are shown the lower right-hand corner of Plate III. Seventeen were from een stalks and had the ordinary color of husk and cob. Two of ese ears are shown at 1 and 2. They are, perhaps, a trifle smaller an the average ears of the whole crop and of remarkably good ape. Three-quarters of the grains are yellow and of a desirable ngth—that is, the percentage of grains to the mass of the ear is r above the average. Samples of the forty-two ears with purple "Ruby") husks and cob are shown at 3, 4 and 5, the latter being e of the largest, and showing the blotching of the "blood" in the ains, which makes the white grains more conspicuous here than sewhere.

It would seem, in the case of the ears, that Mendelism is evident r the numbers for dominant "Ruby" and recessive white are osely approximated. With this in mind, it is hoped to get a oss between the "Ruby" and the "yellow" along at least four nes, namely, (1) "Ruby" plants with yellow grains; (2) "Ruby" ants with white grains; (3) green plants with yellow grains, and 4) green plants with white grains. It remains to be seen whether, hen this is done, the vigor of the plant, time of bearing, crop, ze of ear, &c., will remain constant in the four strains.

The table qualities of this cross demand a word because the cob of the "Ruby" type) is of a dark, almost "blood," color, and in is respect is objectionable to some. When the ears are served is seems to be intensified, but the cooking does not discolor the ains, which are quite white, unless they were tinged at the itset.

"Golden Bantam-Livingston's Evergreen" (34/47).—There as only a very limited amount of the seed of this cross, and, to oid contamination, it was planted late (June 26th), and, from cessity, upon poor soil; the young plants started out well, but ey remained small and gave a very inferior crop.

"Golden Bantam" upon "Mexican-Gentleman" (34//99/19).—he white grains only of this double cross were planted, and, ving to unavoidably unfavorable conditions, only an inferior eld was secured. No yellow grains were in evidence, and therere, in this case, the black of the "Mexican" and the yellow of

the "Bantam" had both been eliminated by selecting the recessive white grains for two generations. The zigzag of the "Gentleman" was present to a small extent, and chiefly at the tips of the ears.

"Golden Bantam-Country Gentleman" (34/19).—This cross involves a very striking difference in the size of plant and ear arrangement of the grains and time of coming into bearing. The thirty hills were planted, purposely, late, to secure their freedom from mixing with another early block of corn, grown nearby. The conditions were unfavorable for a good crop and only thirty ears of suitable size for seed were harvested, all having three-fourths of their grains yellow. Only seven showed the zigzag type of the "Country Gentleman," while nine were straight-rowed and the remainder had the rows somewhat irregular. In the lower part of Plate II. the male parent is shown at 1 and the mother type at 4, with 2 and 3 as fair samples of the kinds of ears that were obtained by the cross. The shape is good, perhaps better than that of either parent, and is somewhat like a boat, with the butt narrowed in and the upper portion tapering slightly to the end. This is a desirable form of ear and the size is satisfactory if it can be produced early and two ears upon a stalk. Owing to the small size of the block no test of the table ears was made, but the extremely high quality of the "Country Gentleman" parent is much in its favor.

"Golden Bantam-Stowell's Evergreen" (34/83).—Thirty hills of this cross were planted late (June 9th) upon land where winter squashes failed, and being somewhat in the shade of large maple trees, did not have a fair chance. At harvest time the three-quarters of yellow grains was apparent. Practically one-fourth of the ears were eight-rowed, like the male parent, and the others had ten, twelve and more rows of kernels. Upon these latter, in particular, the long and much desired type of grain of the "Stowell" was present, and the hope is indulged that, by selection, either a white or a yellow strain (as desired) may be obtained that will be both early and still have a small cob with a large percentage of the edible portion. In the lower part of Plate II. the male and female parents of the cross in question are Nos. 1 and 7, respectively, while the ears at 5 and 6 are selected types of the crosses. The one at 6 may give a larger crop than 5, but more than likely at a loss of speed in coming into table condition.

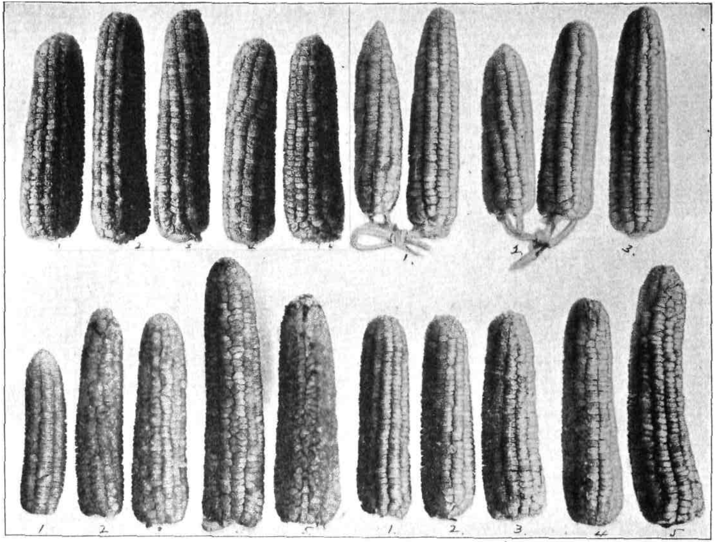


PLATE III.

EXPERIMENTS WITH VARIOUS FLINT CORNS.

During 1905 a list of thirty-one (Nos. 106-136) popcorns made up a breeding block, in connection with which the "Black Mexican" was grown in order to secure crosses with a characteristic dark sweet corn. From the above plot a long list of crosses was obtained, and for the study of these space was given upon the Home Grounds for only five.

"Queen's Golden-White Rice" (114/129).—A set of five ears from a cross of the "Queen's Golden" (114) upon "White Rice" (129) is shown in the upper left-hand corner of Plate IV. This cross produced strong, leafy plants with medium-sized stems that grew eight or more feet high and bore the ears fully five feet above the ground. The tassels were particularly noted as being of unusually large size, and drooped throughout the blooming period. In size of plant, large leaf surface and small stalks for the height, this cross seems to possess value as a forage crop. The ears matured fairly early and were of good size, although the situation was not favorable for a good crop, the plants being near a row of maple trees and, besides, the soil was poor.

Many of the ears harvested were with round-tipped grains instead of being of the "Rice" type, that is, with the free end sharp-pointed, sometimes disagreeably so when the ear is drawn tip foremost through the hand. Ears 1, 3 and 5 in the engraving are with the grains smooth, while the alternating ones are of the genuine "Rice" type, with the one at 4 having the kernels much larger than in the other at 2. This character of the grain tip is one that pertains to the whole ear. Of twenty-seven ears taken at random, seventeen had smooth-tipped grains, seven of the "Rice" type, and three somewhat intermediate. It is possible that several strains of popcorn, varying in color and shape of grain, may be obtained from the cross in question.

"Adams-Black Mexican" (3/99).—The second cross, figured in the upper right-hand corner of Plate IV., is of the "Adams" upon the "Black Mexican." The color of the "Mexican" is clearly dominant, and gives to all the ears a heavy percentage of dark grains, but with some range of variation, as instanced in ears 2 and 3. The shapes of the ears vary greatly, some of them being short and small in diameter, like the "Mexican," as shown at 1, while others

are nearly of the "Adams" type in size, shape and character of large, square-tipped, dented grain, as seen at 5. In number of rows there was very little deviation from twelve, so it would seem in this respect that the "Adams" has greater prepotency than the "Mexican," which is strictly an eight-rowed sort. Nearly all the ears were solid flint, but in a few 10 per cent. or so of the grains were wrinkled. The reason for this lack of uniformity among the ears is not evident.

"Pop-Black Mexican" (x/99).—An exceedingly variable block of corn was obtained by planting the flint grains obtained from a row of "Black Mexican" that was grown among a long list of the various pop varieties. In the lower left-hand corner of the plate is shown five sample ears. The one at 1 is a very neatly-shaped specimen, the grains of which show many shades of dark, light pinks being common. The indications are that the male parent was a "white pearl," which gave a fourteen-rowed ear, partaking strongly of the "pearl" type. One-quarter of the grains are wrinkled, and when separated may give some desirable qualities in a sweet corn. At 2 is shown an ear that has three-fourths of the grains dark and one-quarter yellow. The yellow color is not entirely obliterated by the black, and therefore in this type of crossed ear it may be possible to separate out the pure blacks as well as the pure yellows, leaving the 50 per cent. of the hybrids. In the picture the prevailing yellow color causes the ear (2) to be darker than it naturally appears. The third (3) ear is one of several that were harvested—all of them short, with many rows of square-tipped grains with a prevailing lemon yellow color. This appears to be a result of the crossing of a lemon yellow sort (120) from India, which was a very distinct type in the list of sorts grown last year. In the engraving the light yellow shows nearly white, so that the ear looks less colored than it really is. The wrinkled grains are also clearly seen.

The ear at 4, there appearing black, is a dark wine red throughout excepting the quarter of grains that are evidently pure black. In this instance the red is an ear character instead of belonging to the individual grain, and the red color is apparently only visibly overcome when the grains are of pure black "blood." Here, as elsewhere, one-quarter of the kernels are of the wrinkled sort, and one-fourth of these—that is, one in sixteen of the total—are black.

Further growing of plants from dark ears may lead to considerable further complications.

At 5 is a long, slender, eight-rowed ear, the parentage of which is not far to seek, for it agrees almost exactly in shape with the variety of popcorn known as the "Eight-Rowed," and was one of the sorts represented in the breeding plot the year before. The wrinkled grains are somewhat longer than the others—a fact still more evident in the next set of crosses, and will be mentioned again.

"Black Pop-Country Gentleman" (137/19).—The remaining set of ears in the plate represents samples from the cross of "Black Pop" upon "Country Gentleman," and, of course, are of two widely different parents. The notes during the growing season show that the plants were of large size, with stout stems that came into bloom during the middle of July, bearing very large, reddish, drooping tassels and dark purple silks. There were many suckers that reached beyond the slender ears that were borne low upon the stalks. The harvest was upon September 13th, and the record states that there was a fine lot of fairly uniform ears, three-fourths of the grains of which showed the dark color of the popcorn parent. An attempt was made to show, as far as possible, the gradations between the two parents, with the type of ear most nearly like the "Pop" upon the left (1), while the tapering, somewhat curved, form of the mother is given at the right (5). The ears shown at 2, 3 and 4 are representative of the majority of the crop. It is seen from this that the popcorn, which has a slender ear with twelve or more rows of short grains, controlled largely the shape of the ear in the cross. The zigzag disposition of the grains in the "Country Gentleman" is evident in only a small per cent. of the ears, none of them being strictly of the type of the mother. Where the grains were irregularly placed this arrangement was confined to the upper end of the ear, as shown at 3 and 4. The difference between the grains of the two parents is shown in the cross, the black ones, for instance, being shorter than the white wrinkled ones, the latter standing above the flint grains even after the former have undergone the usual shrinking of "sweet" kernels. The same fact of the influence of the parent upon the size of grain in ears resulting from a cross has been observed a number of times elsewhere. By placing a dry ear in a moist place until the grains are fully swollen, the difference in length is emphasized, and the same

result may be obtained by letting the shelled grains undergo swelling, as, for example, in advance of germination.

A block of a cross of "Black Pop" upon "Zigzag" sweet corn was grown, but it was too near a row of maple trees to give satisfactory results. The small ears secured, however, showed the usual three-quarters of the dark flint grains, and nearly all had the rows usually fourteen, distinct excepting occasionally at the tip, where the grains were irregularly placed. The exceptional ears were of the true zigzag type, and suggest the thought that the straight-rowed ear is the older or original arrangement of the grains and the zigzag is a recessive type. Some of the ears had the grains with sharp tips, resembling the "Rice" type of popcorn, but those with rounded or smooth tips were in the large majority.

A PRIMARY BREEDING PLOT OF SWEET CORN.

The following twenty-eight (28) numbers occupied the north-east corner of the New Land, that is, the eastern end of Strip III. *Each number made a row of fifteen hills across the strip.* The breeders were "Cory Red Cob" (16) and "Pride of Nishua" (145), which make Row 5, cutting all other rows at right angles, and a yellow sort from Rhode Island (142) with "Silver Mine" (144), the latter two making Row 10, parallel with Row 5. In other words, hills 5 and 10 of each row across the strip were passed over in the general planting and afterwards filled in with the *breeders, as above stated. Each of the two breeder rows contained alternate hills of the two sorts, namely, breeder row 5 had the odd* hills of "Cory Red Cob" and the even hills "Pride of Nishua," and breeder row 10 received for odd hills the "Rhode Island Yellow" and for even hills the "Silver Mine."

The point in particular was to study the standard varieties of sweet corns as to characteristics and expose them to the pollen of all of the breeders. The "Cory" differs from all other varieties of sweet corn in the plot in having its grains of a reddish yellow upon a cob of the same color. The "Pride of Nishua" is a standard field corn, the seed ears of which were secured from a corn breeder in Iowa. In this the grains were yellow upon a cinnamon-colored cob. The "Rhode Island Yellow," as its name suggests, is a genuine sweet corn with the yellow grains, and the "Iowa Silver Mine"

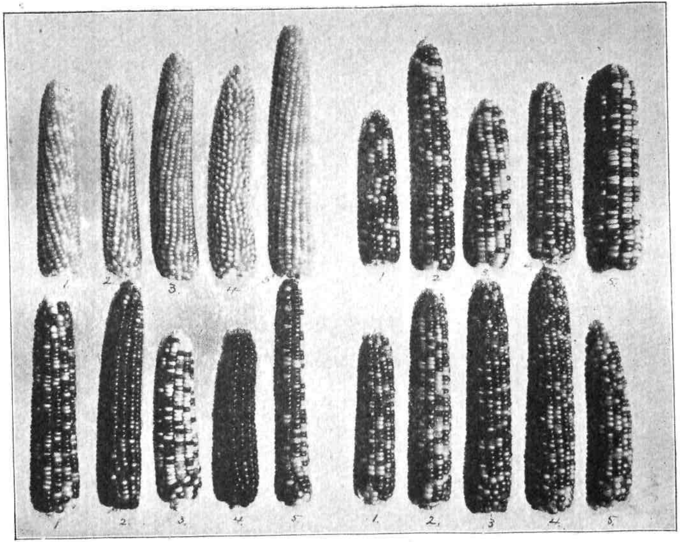


PLATE IV.

one of the leading white dent varieties grown in the West, and as, with the "Pride of Nishua," obtained from a large breeder of orn in Iowa. The set of twenty-four varieties of sweet corn was elected to be fairly representative of the various kinds, with the exclusion of any having other than a white colored grain and cob.

Row 1. "*Banana*" (6) Farq. It was somewhat unfortunate for this variety that it came at the end of the plot and was damaged thereby, so that only a small crop was secured. Plants came into bloom upon July 20th, showing a brownish tassel and red silk. The harvest was secured upon September 10th, showing that it was medium early. A sample of each kind is shown in Plate V., the "Banana" being at 1.

Row 2. "*Champion*," early (11), P. H. & Co. A good stand of medium-sized plants was secured, which showed purplish tassels upon July 13th, and the pink silks were past maturity upon the 27th. The fifteen ears, secured on September 6th, were of fair size, were borne low upon the stalk and contained twelve or more rows of fine, long grains, as shown at 2.

Row 3. "*Country Gentleman*" (19) Farq. Upon August 4th, it was noted that the plants were quite uniform in size, with the pinkish tassels and silks appearing. The harvest was secured on September 11th, when it was noted that the stalks were quite tall and the number of fine ears was limited to eight.

Row 4. "*Country Gentleman*" (19) P. H. & Co. This row was planted with seed from another dealer, and proved to be a better row in some respects than the previous one. It was not quite as early in maturing and the harvest (six days later) gave fourteen fine ears. The small ones, perhaps due to inferior situation, in all of these rows have been discarded in the count. A sample ear is shown at 3.

Row 5. "*Crosby*," early (20), Farq. This quick-growing and small variety was in tassel on July 6th and in full bloom upon the 20th, with tassels straw-colored and silk green. The harvest was upon August 30th and a sample ear is shown at 5, being the best out of the six obtained.

Row 6. *"Crosby,"* early (20), P. H. & Co. This row was practically the same as the previous one in earliness, smallness of plants and meagerness of yield, there being only five good-sized ears.

Row 7. *"Henderson"* (39) P. H. & Co. This gave a fine row of tall, stout plants, producing many suckers, and came into full bloom, with tassels purple and silks varying from green to pink, upon July 27th. The mature ears were gathered upon September 10th, yielding thirty ears, a fair sample of which is shown at 7. This was one of the best rows in the whole plot. So far as yield is concerned, no test was made in any case of the quality of the table corn.

Row 8. *"Hurd's Hiawatha"* (41) P. H. & Co. This was a good row, considering the circumstances, with the plants of good height, the upper leaves particularly broad and fine, and was in bloom, with pink silks and straw-colored tassels, upon July 27th. The harvest was made on the 11th of September, when twelve ears were secured, an average sample being shown at 8.

Row 9. *"Hickox Improved"* (42) P. H. & Co. This was an even row of five plants, marked "tall" in the record book, and had an unusually long blooming period, beginning upon July 20th. The mature ears were secured upon September 14th, one of the twelve of good size being shown at 9.

Row 10. *"Mammoth,"* (early) (49), P. H. & Co. This gave a row of tall, leafy plants, the tassels of which began to appear upon July 27th, and were in full bloom on August 4th. The mature crop was harvested upon the 11th of September, when fifteen large ears were taken, a sample being shown at 10.

Row 11. *"Mammoth,"* (late) (50), P. H. & Co. This proved to be practically the same as the above row, although not as good. The crop was harvested upon the same day as the last and only eight large ears were secured, one of which is shown at 11.

Row 12. *"Metropolitan"* (57) C. H. Lilly Co. This uneven row of plants, in some measure due to the character of the soil, came into bloom, with purple tassels and pink or green silks, upon July 27th. The harvest was secured upon September 11th, there being nine good ears, one of which is shown at 12.

Row 13. *"Metropolitan"* (57) P. H. & Co. This row differed somewhat from the last named and the harvest consisted of ten sizeable ears, one of which is shown at 13.

Row 14. *"Minnesota Early"* (58) P. H. & Co. The note-book records for this: "A good row; in tassel July 13th, with purple tassels and pink silks; the harvest was upon September 2d," showing its earliness, when eight ears were secured, one of which is pictured at 14.

Row 15. *"Moore's Early Concord"* (61) P. H. & Co. This was a good row of medium-sized plants and began to bloom upon July 20th, having purple tassels and silks, the latter varying to green. The harvest was upon September 5th, when ten ears of the size shown at 15 were secured. This was one of the best rows of the earlier varieties.

Row 16. *"Ne Plus Ultra"* (62) P. H. & Co. Several of the hills were without plants in this row and no replanting was made, so that the plants were comparatively few. They were medium in time of bloom, namely, July 27th, the plants being rather short and stout. Only six good ears were secured September 6th, one of which is shown at 16.

Row 17. *"Old Colony"* (64) P. H. & Co. Unfortunately, this row, and two or three others, were in the area infested with quack grass, which undoubtedly interfered with its development. The plants were variable, coming into bloom, with purple tassels and pink silks, upon July 27th, and were ready for harvest on September 11th, when ten ears of the type shown at 17 were secured.

Row 18. "*Squantum*" (69) P. H. & Co. This was only a fair row of uneven plants, beginning to bloom upon July 20th, with purple tassels and pink silks. The crop, however, was above the average, there being sixteen ears gathered upon the 14th of September, and these were of a satisfactory shape, as shown in 18.

Row 19. "*Premo*" (71) C. H. Lilly Co. This was a poor row of plants, which were in full bloom upon July 20th, with purple tassels and silks, varying from pink to green. Five ears were harvested on September 11th, one of which is shown at 19.

Row 20. "*Shaker's Early*" (78) P. H. & Co. The plants in this row were of good size and bloomed upon July 20th, showing straw-colored tassels and green silks. The harvest was upon the 12th of September, when only six ears of fair size, as shown at 20, were secured.

Row 21. "*Stabler's Early*" (81) P. H. & Co. This row of medium-sized plants began to tassel upon the 13th of July and had a long period of blooming. At harvest time, September 10th, ten ears of a long, slender type, as shown at 21, were secured.

Row 22. "*Stowell's Evergreen*" (83) Farq. This was a fair row of broad-leaved plants, which were in full bloom upon August 4th. The harvest was upon the 17th of September, when seven good-sized ears, as shown at 22, were obtained.

Row 23. "*Stowell's Evergreen*" (83) P. H. & Co. This row was not as good as the one preceding; somewhat earlier and smaller, but yielded the same number of ears upon the same date of harvesting.

Row 24. "*Guerin*" (143) Guerin. This end row was made up of medium-sized, slender plants, which came into full bloom on the 20th of July, bearing purple tassels and pale-green silks, and, upon the 11th of September, gave a harvest of eleven long, slender, eight-rowed ears, as shown at 24.

The seed used in all of the above twenty-four rows was taken from sample ears, secured from the dealers whose initials are appended to the name of the variety. These ears are preserved in the Museum of the Department for the sake of ready reference to the type of grain, ear, &c., that was used in each case.

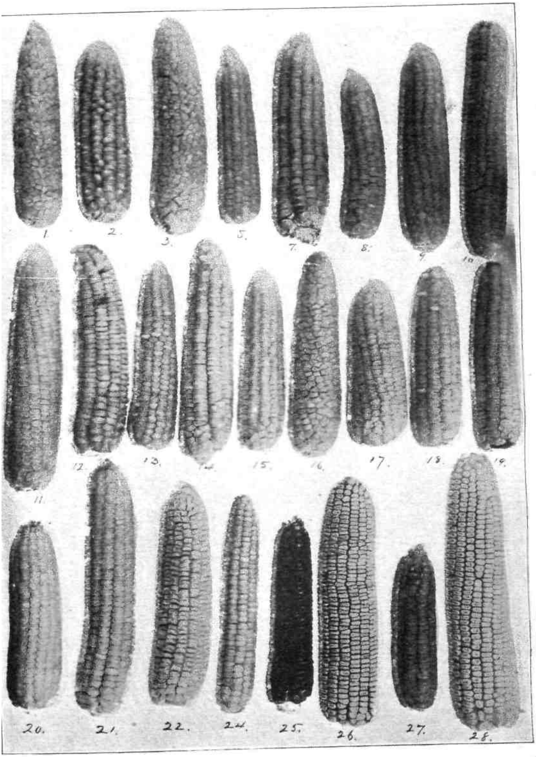


PLATE V.

Sample ears of various commercial varieties grown upon poor soil during 1906.

The Four Breeders.

The "Cory Red Cob" (16) is a small, early variety, and upon the poor soil it hastened to maturity. An ear is shown at 25, where the red color of the grains appears nearly black. It was noted that the color of the grain of this variety, as expected, was not marked upon any of the surrounding kinds, and the fact of a cross can only be determined in the future crop.

The "Pride of Nishua" (145), as before stated, is a large and choice field variety of dent corn secured from Iowa. It grew to the height of nine to eleven feet and bloomed later than the surrounding sweet varieties, but some grains of it, crossed upon the sweet neighbors, were obtained for a majority of the varieties. The size and general appearance of this corn may be determined from the ear shown at 26. Whether the crosses thus secured will have the great vigor of the "Nishua," combined with the full sweetness of the table sorts, is problematical.

The "Rhode Island Yellow" (142) proved too small and early to permit of many crosses being secured. One of the largest ears is shown at 27, which is in striking contrast with the larger field sorts upon either side.

The "Iowa Silver Mine" (144) was a very strong grower and made stalks that overtopped the sweet corns among which it grew. The longer growing period and lateness of blooming interfered with the crossing, so that only an occasional grain of white dent was found in the ears of the sweet sorts. As the ear at 28 shows, this white dent variety is larger than the "Nishua," and far outmeasures the ears of the various sweet kinds.

"BLACK MEXICAN" AND OTHER CROSSES—CO-OPERATIVE TESTS.

In response to requests for samples of crossed corn, thirty-six packets were distributed last spring. From the reports rendered up to the date of writing (November 10th), the following notes are condensed. (The color of seed grains planted in each case follows the name of the cross.)

"Mexican-Banana" (99/6). White grains. Hon. James Neilson reports upon his test for this cross as follows: "A very good,

medium-early corn; planted at same time as 'Stowell's Evergreen,' was ready five days earlier; height, six feet; flavor good and very tender." The dozen and more of sample ears brought to the Experiment Station were all pure white and showed but little of the zigzag tendency.

"Mexican-Banana" (99/6). Black grains. Mr. George M. Hoffman reports upon his test of this cross: "Ears are small; did not have very good success with this cross." From the few ears sent in, it is evident that the usual amount of white "blood" was concealed in the dark seed, and that the straight rows of the "Mexican" prevailed over the zigzag of the "Banana."

"Mexican-Gold Coin Evergreen" (99/26). Black grains. Mr. W. T. Woerner writes of his test with this cross: "Planted May 17th, ripe September 15th; quite prolific; one and two ears to the stalk."

"Mexican-First in Market" (99/31). Dark grains. Rev. William F. Bond reports that: "The success with this corn was all that we could expect; it was a very special favorite on our table; we were well pleased with the experiment and the results."

"Mexican-First in Market" (99/31). White grains. Mr. M. S. Crane writes: "Some of the ears kept show a spattering of dark blue kernels, also a few white and yellow ones." The three ears sent in are all of good size, twelve to fourteen rowed, and with all the grains white. There was likely a kernel planted bearing black "blood."

"Mexican-Hiawatha" (99/41). White grains. Mr. Frank Bingham reports upon his test of this cross as follows: "Vigorous but black corn does not sell well here." The four ears sent in are solid white, with one exception. The chief fault with them is a tendency toward flintiness, seen particularly in one ear.

"Mexican-Kendel's Giant" (99/44). White grains. P. B. Randolph & Son report: "Planted April 30th, in fairly good soil; reached condition for table by August 1st; ears twelve-rowed, seven to nine inches in length; quality excellent, very sweet; the stalks grew two different heights—five and seven feet." From the ears submitted it is seen that there was a little black "blood" present. The matter of two sizes of stalks will require further investigation.

"Mexican-Maule's XX." (99/55). Black grains. Mr. J. E. Kuhns reports as follows: "Planted May 15th; first edible ears

by August 1st; strong grower; two good ears on most stalks; quality excellent at its best stage." The ears sent to the Experiment Station were fine and showed the usual percentage of white grains. Some of the kernels showed some excess of starch, but probably not due to mixture in the field.

"*Mexican-Roslyn Hybrid*" (99/75). Black grains. Mr. F. B. Kilmer reports upon this cross as follows: "This corn grew well; about five and one-half feet high, about two ears to each stalk and was of excellent quality for eating—in fact, those who used it state that it was the best sweet corn which had ever been produced." The package of ears brought in showed that the cross was far from fixed, and that there was much hope, by selection, of securing a desirable sort.

Mr. A. R. Lewis grew the same cross and color of seed grains, and "used twelve ears for the table and the corn gave entire satisfaction." Six ears were sent to the Experiment Station, and of these three were solid black and the other three showed a small percentage of white, and, in addition, one of the last-named had an admixture of yellow dent that, it is inferred, came from some field corn growing in the neighborhood. This last ear is particularly interesting, because it shows the blending of the dark and yellow color in all the dark flint grains. In other words, these grains carry the starch and the sugar characteristics—the latter hidden or recessive, and two colors, both in sight—and furnish a stock for breeding and selection.

"*Mexican-Garwood*" (99/94). Black grains. Mr. Henry R. Jones reports upon his test of this cross as follows: "Yield was very good and it was fit to eat about the same time as other corn that was planted two weeks earlier; very much pleased with the corn; a very delicious table corn."

The same cross from white grains was grown upon the Home Grounds and showed much of promise. It is mentioned elsewhere.

"*Golden Bantam-Marblehead*" (34/51). This cross was grown by Mr. W. B. Cook, who sent a very attractive ear—almost ideal, barring, perhaps, a taper that some growers and experts object to. All the crop was accidentally destroyed excepting this single ear, and therefore another generation will need to be grown before seed can be offered for testing. Mr. Cook writes: "We tested it on the table and it was very good." This is a promising cross.

true and be recessive, while the red ones produce a small number of white ears, showing that the red color behaves like a dominant character.

Cross of "Eight-Rowed" and "Black" Pop Corn (121/137).

The seeds of the two parents, "Eight-Rowed" and "Black Pop," were grown in alternate rows, in isolation, by Mr. William H. Reid, who sent to the Experiment Station last year a quantity of the "Eight-Rowed" sort, very thoroughly mixed with the "Black," but the grains showing the combination were pinkish, and not of the black of the male parent. The amount of the discoloration of the white grains varied greatly, in some kernels it being only slight, and seen with difficulty, while others were a dull, dark red.

The grains showing the cross were planted this year by Mr. Reid, and the twenty-four ears at hand are quite uniform in having three-quarters of the grains discolored and the remaining quarter white. It is noted that some ears have the discolored grains of two general groups, namely, those that are solid black and others with less darkness, making it possible to hope the pure black may be separated at once, as well as the pure whites, leaving the hybrids by themselves. A student kindly selected and counted the grains upon four average ears, with the result that 463 were black, 554 white and 827 mixed, thus giving the following percentages: Black, 25.1; white, 30.0, and mixed, 44.9. It is seen that the white exceeds the theoretical amount, but the fact that the quarter of presumably pure black grains can be separated seems to be demonstrated in this case. It remains to show by process of cropping that the black grains, thus separated, are true to their color. Some ears have a blackish red for the pure dark grains, the presumed hybrids varying to a lighter shade, accordingly.

It is further noted that eighteen of the twenty-four ears are ten or more rowed, like the "Black" parent, and six are eight-rowed, like the white parent. In other respects, difficult to define, the ears are of two types, strongly suggesting the parent that has a controlling influence in the cross. Should all crosses between a distinctly eight-rowed sort and one with a larger number of rows result as the small set in this cross, it would point toward the number of rows being a Mendelian character.

The cross gives a marked increase in size over either parent, a fact not unusual in the crop the first year after combination.

"Voorhees Red" Sweet Corn.

Another season has been added to the period of testing of the "Voorhees Red" sweet corn, and the reports are very favorable, as a few of the remarks given below, from some of those who have grown it for years, will testify: "The average height of the crop of 'Voorhees Red' was eighty-eight inches; the yield of the whole crop, per acre, was fifteen tons; the uniformity was good and the color between a red and a purple." "Average height of stalks, six feet; average number of ears to a stalk was three, sometimes five; sets well filled, quality very good; with more time and more selection, seems to promise to be one of the best." "The 'Voorhees Red' is a fine corn and I shall continue to grow it." "'Voorhees Red' turned out well this year." "Corn was sweet and nice; stalks were from five to six feet high, with two ears to a stalk." "Ears good size, filled out to the end, one to two ears to a stalk; grains good size, light red to dark red in color, when fully ripe, showing only a faint trace of red when fit for the table; quality sweet and good; will grow it again next season." "Seed germinated promptly; good stand; stalks six to seven feet high; first planting matured in August; was away when corn was ripe, but neighbors who used it say it was the sweetest corn they ever ate; second planting matured in September; furnished seed to two neighbors, who are pleased with the corn; I regard it as excellent and have saved seed for next year." "'Voorhees Red' did very well with us; the grains were very nearly all of a size; we like the corn very much; ears very sweet and tender, and two ears on most stalks." "I like this corn in every way." "Ears fill out better than ordinary sweet corn and will yield better." "Corn has made a most excellent showing and is all that could be desired; very sweet and productive." "Corn is much in favor; ears of good flavor and tenderness." "'Voorhees Red' corn came up well and grew nicely; stalks of good height; eared well, averaging about six inches in length, of good size for table corn; we ate some of it for a test and found it very sweet and tender; am so well pleased with it that I saved about twenty ears for seed, part of which I intend giving to some of my friends to try next year, as I feel that I can recommend it for table use as a very satisfactory addition to the many varieties of sweet corn." "Quality

good and sweet." "The 'Voorhees Red' sweet corn did well this season; the stalks were from five and a half to six feet, bearing from two to three ears to a stalk; ears full, of medium size and deliciously sweet." "The quality is not changed, unless it is more tender; it is the very best sweet corn in existence and you should be proud of producing such a variety." "The choicest corn I ever ate." "Sweet and delicious in flavor." "The 'Voorhees Red' sweet corn was valued highly."

GENERAL NOTES UPON CORN.

When the straight-rowed varieties are bred with those of the zigzag type, as has been done in many instances, the blend plants *produce ears that show a strong preponderance of the straight* rows. In some cases there may be only an occasional ear that is entirely zigzag, but as a rule there are many with the upper third of the ear with the grains irregularly disposed. Whether the relation between the two types of grain-arrangement can be expressed in any fractional form or ratio remains to be seen. It would seem that the straight-rowed type is the primary one and the zigzag is a later development, that in crosses between the two, in some cases, persists in the ear tips. The possibility of obtaining by selection a variety with the double type constantly present is not, perhaps, without hope, even if it is without manifest profit. The origin of the ear is a natural subject for inquiry in the face of these commingling types.

Mr. *Montgomery, of the University of Nebraska,* has recently* presented an opinion that the modern corn ear has developed from the central spike of a tassel. This view presumes that "the progenitor of the corn was a large, much-branched grass, each branch being terminated by a tassel-like structure, bearing hermaphrodite flowers. * * * As evolution progressed the central tassel came to produce only staminate flowers * * * and the lateral branches came to produce only pistillate flowers." Several engravings are given of "sucker" ears, in which stages in the development of the central spike of the tassel into an ear of corn are given, stages that in a general way are familiar to all who have knowledge of corn in the field. As the male flowers are borne

* "What is an Ear of Corn?"—Popular Science Monthly, January, 1906.

in pairs and in from four to eleven rows, by replacement, the grains consequently are in double rows, which is clear so far as the straight-rowed ears are concerned. In the zigzag ears, when the kernels are removed, the cob shows that by a slight displacement the young grains are developed out of line, and, by pressure, the mature kernels may take on the irregular ("shoepeg") form. If this view be the true one, the zigzag type is in a degree accidental and might be expected, as it is found occasionally in many kinds of corn, but that, by selection, it can be fixed as a varietal characteristic is not in violation of a general rule.

The study of corn blends is not without its points of interest. There is a wide difference in varieties as to the influence had upon the cross. In some instances the plants are not widely different, to begin with, and the results are accordingly meager. It goes without saying, in other words, that in order to have an interesting cross, there needs to be two or more characteristics that are not in common. The crossing, for example, of the "Black Mexican" and the "Egyptian," which, while differing in minor points (as shape of ears, rows upon the cob, &c.), were very unlike in the color of the grain, and the result is a kernel of a dark red color, which is entirely unlike either parent. It seems to be a creation in the cross, and, in time, it is hoped to demonstrate what effect the "Voorhees" will exert upon white and other sorts of sweet and field corns. It is possible that, in breeding, its crosses may not show the same red color, but, instead, possibly the black of the "Mexican."

The breeding of the "Golden Bantam" upon the "Banana" has been interesting in that it furnished a block of very variable plants, in height, time of maturity, form and size of ears and the disposition of the grains upon the cob. A large number of the small, early plants can best be understood by accepting the view that they were from grains of pure "Golden Bantam," that for some reason, not yet explained, were mixed with the crossed kernels. With those eliminated, there still remains a great diversity of plants. The few late ones, green after all others were mature, had large, zigzag ears, in striking contrast with the mass of straight-rowed ears, but all alike in the three-quarters of yellow grains.

This cross, in its blend generation, where similarity is looked for, is a good illustration of the greater size of the product than obtains with either parent. The "Golden-Bantam" is, as said, a

small variety in every way, and the "Banana" produces ears, as a rule, smaller than the "Country Gentleman," but in the crop obtained in the blend they were more nearly the size of the "Stowell's Evergreen" and varieties of that type.

There is a tendency to produce suckers in the blend plants, exceeding that in the parents and far beyond that of the plants that follow in after years. In short, the vigor seems to be much enhanced by the operation of the cross, and it may be true, and evidence points that way, that the wider the cross among varieties *the greater the increase in vital activities.*

The crosses of sweet and pop corns were wide, indeed, and here the blend plants, even upon very poor soil, grew vigorously, and, where possible, produced ears that outmeasured the average of the parents. Thus the "Black Pop" upon "Country Gentleman" produced ears exceeding in length the average of the two varieties involved, and under the same circumstances their progeny may fall far short of the same dimensions.

EXPERIMENTS WITH TOMATOES.

Old Varieties Grown the Present Season.

The number of commercial varieties of tomatoes grown the present season is much reduced from that of the two previous years. The list includes only the parents of the crosses that were selected for testing in the Gardens, to which was added the novelties that appeared for the season of 1906. The following is the list of the parents, entered here without comment, as the notes upon them have been given in previous reports:

1. "Acme."
4. "Arcadia."
6. "Atlantic Prize."
8. "Beauty."
14. "Bright and Early."
15. "Brinton's Best."
21. "Climbing."
26. "Crimson Cushion."
28. "Cumberland."
29. "Dominion Day."
32. "Duke of York."
33. "Earliana."
42. "Early Ruby."
44. "Enormous."
49. "Favorite."
53. "Fortune."
54. "Freedom."
55. "Frogmore."
56. "Giant."
57. "Giant Climbing."
60. "Honor Bright."
63. "Imperial."
64. "King Humbert."
66. "Jewel."
75. "Magnus."
77. "Marvel."
85. "Michigan."
87. "Minnesota."
90. "Mikado."
98. "Paragon."
103. "Ponderosa."
110. "Quicksure."
119. "South Jersey."
121. "Stone."
143. "1903."
145. "Golden Queen."
147. "Lemon Blush."
148. "Yellow Prince."
149. "Aristocrat."
153. "Champion."
156. "Champion Scarlet."
158. "Dandy Dwarf."
159. "Extra Early Tree."
169. "Dwarf Stone."
172. "Gold Ball."
175. "Ivory Ball."
177. "Red Currant."
179. "Red Pear."

Novelties or Varieties Not Before Grown in the Gardens.

o. 213. "Laycock." This was obtained from the originator (whose name it bears) in England, as it was reported to have exceptionally desirable qualities. The plants were of the normal type, with somewhat longer stems than the average standard fine-leaved sorts. The fruit, of the ordinary "red" color, was medium late in maturing and was not abundant. In form the tomatoes were somewhat longer than the average upon one plant, suggesting that it contained the "King Humbert" "blood," and, along with it, a flabbiness that is not desired. In breeding with varieties with solidity of flesh and minimum seediness, it may prove of value in lengthening the axis of the fruit.

o. 214. "Earliana" (Strain No. 10). This was offered as an *improvement upon the "Earliana," now a recognized* leader in the State as an early productive variety. It was somewhat superior to the regular type in showing less of the concentric cracks upon the shoulder of the fruit, but there was some loss in yield and a tendency to a long bearing season.

No. 215. "Earliest Pink." This variety was true to name in yielding a pink fruit, but it did not produce them very early or in great abundance.

No. 216. "Hubert's Marvel." In this variety there was suggestion of lack of fixity of type. The plants were only of fair size and the fruit was usually under the desired size.

No. 217. "June Pink." This sort has earliness as its leading quality. The record for July 7th shows the first ripe fruit. Upon the 11th of September the record is that the variety is not very desirable.

No. 218. "Jerrard's New." The plants were of medium size and matured their fruits among the first of all. Other than earliness, the variety has no great merit.

No. 219. "Greater Baltimore." For some unknown reason, the plants of this novelty were lacking in vigor and did not do well. An improvement was noted later in the season, when a fair crop of good-sized fruits was produced.

The "Puget Sound Special" (211), grown last year from seed obtained from the Northwest, was given a second trial from home-grown seed, but, as before, the plants (of dwarf type) were not desirable.

Notes Upon Some of the Leading Crosses.

The "Magnerosa."

The "Magnerosa" was grown in considerable quantity during the season of 1906 and in the following combinations of the parent sorts: 75/103, 75//75/103, 75/103//75 and 75/103//103.

The fractions indicate that 75, which is the record number for "Magnus"—a standard, coarse-leaved, pink-fruited variety—was crossed upon 103, the number for "Ponderosa," a standard, fine-leaved, pink-fruited sort. The original cross, made in 1903, has been grown each year from selected plants, both in the field and greenhouse, thus getting two crops a year, until a fair degree of uniformity is obtained. The second fraction indicates that the "Magnus" has been bred to the cross just mentioned, so that the offspring of 75//75/103 may be said to be three-quarters "Mag-

nus" (75) to one-quarter of "Ponderosa" (103). The reciprocal to the last is where the cross is bred upon "Magnus," as indicated in the compound fraction, 75/103//75, the double line being the division lines of the second combination. The second fraction, given at the outset, is readily interpreted as a cross of the "Magnerosa" proper upon the "Ponderosa," as indicated by the double lines. The last-named cross shows too great a preponderance of the "Ponderosa," in that the fruits are too large, flat and rough—that is, ribbed and corrugated—and do not ripen evenly. In short, this combination is only a slight improvement over the "Ponderosa," and, while this row was very prolific, no seed from it was saved.

From a study of the two reciprocals with the "Magnus" three-quarters, it is seen that the fruits are remarkably fine, being smooth, quite apple-shaped, and, of course, always pink. From these rows seed from selected plants has been saved, and from one plant in particular that, with its superior fruitfulness, showed a much-desired length of axis in the fruit.

There are two possible types of foliage in the "Magnerosa," namely, the fine-leaved, or ordinary kind represented in the "Ponderosa," and the coarse-leaved, or "potato" type of foliage of the "Magnus." The fine-leaved type has been decided upon for "Magnerosa," but, as it is not possible to eliminate the coarse-leaved type except by individual separation, there will be "potato" plants showing themselves in diminishing numbers from year to year. These, however, can all be thrown out as seedlings and the field kept to one type of leaf.

Reports from Testers of "Magnerosa" Tomato.

Seed of the "Magnerosa" was distributed, by request, to one hundred and ninety-two persons in the State, and from a large number of these reports have been received by the Experiment Station. The following are some of the comments taken from the replies, the quotation marks separating the remarks in the individual reports: "The 'Magnerosa' tomatoes have developed a very rank growth of strong vines which are heavily fruited." "The tomato is very large, very smooth, ripens fast, uniform in size, hearty and strong, fine flavor and color of beefsteak when cut

apart." "The 'Magnerosa' is a good growing vine and well laden with fruit, smooth, large and good quality." "'Magnerosa' doing well and has set considerable fruit." "'Magnerosa' has proved to be a very good kind of tomato, large, smooth and productive." "Vigorous, sturdy plants." "Shows no blight, very vigorous and productive with a mass of fine fruit." "Plants vigorous growers from start, large leaves, some entire, all foliage dark green; plants well filled with fruit, flavor good, promises to be very valuable, looks to be a good yielder, so far a very desirable tomato." "Plant very hearty, largest fruit nine inches around." "'Magnerosa' tomato is fine, large size, vigorous grower, fine color and flavor." "Twenty to twenty-five tomatoes on each plant, fruit fine-shaped and of a beautiful crimson color, measuring from ten to twelve inches in circumference; certainly very fine; vines are still green and vigorous with blossoms on top at this date; we have more tomatoes than all our neighbors put together." "I am much pleased with this tomato; present outlook very good." "Are of good size and good shape." "A very good shipper." "Tomatoes are now ripe and they are certainly fine; we have also had three other kinds, but these are the best; the uniformity of the fruit seems to be perfect." "Am pleased with it; yield with me is about the same as 'Livingston's Stone,' but think the quality better." "Am well pleased with it; the size is good, and, in my opinion, this tomato has many good qualities." "Promises to be an excellent fruit." "Many fruits large, all fair size." "Tomatoes set out and were ripe in sixty-two days; plants very thrifty." "Am much pleased with the 'Magnerosa' tomato; plant is very vigorous and productive, fruit is large and very uniform; I picked one tomato that measured sixteen inches in circumference." "My customers prefer it to other kinds; is a fine bearer." "I find the 'Magnerosa' far above the average, a very strong grower, good producer, fruit is large, no small ones; the meaty part is very solid and of a very fine flavor; I have a garden of two acres with a large lot of tomatoes and these are in the lead." "Quality is very fine." "The fruit is handsome and am well pleased with it; very showy and solid." "The plants are doing splendidly and are looking as well as any of the other varieties that are growing near them; the productiveness and shape are in every way satisfactory." "A great improvement on the 'Ponderosa.'" "A valuable fruit for

late." "Strong growers and well filled." "'Magnerosa' is doing finely; have picked about five baskets from eighteen plants already and more to come; size large as a Bartlett pear, shape more like a round ball, color red as fire and it keeps well as far as I can see." "The largest fruit weighs half a pound." "They keep well after being picked from vines." "I am much pleased to get so fine a tomato." "Vigor and productiveness of plants excellent." "Quality of fruit is of the best; we never had better tomatoes." "The 'Magnerosa' I am much pleased with." "Very strong growing plants, well loaded with good-sized fruit." "My plants are looking fine with fruit of good size, plants stocky, fruit well formed and has plenty of it; promises to be an excellent fruit." "The plants grew vigorously and on trellis reached over five feet in height, producing bunches of fruit, or clusters of from four to *nine in a cluster and very plentifully.*" "*Holds its good size to* the end of season." "Tomatoes smooth and perfectly shaped and of fair size." "The tomatoes are fine, a good grower and good bearer, flavor fine, fruit firm and of medium size."

The "Marvelosa"—("Marvel-Ponderosa"—77/103)—Station No. 5.

Several rows of two crosses between the "Marvel" (77) and the "Ponderosa" (103) have been grown during the season. The "Marvel" is red-fruited so that, in the cross with the "Ponderosa," a leading difference is in the color of the tomatoes. Another characteristic of note is the shape of the fruit, which in the "Marvel" is medium round and smooth and not over large. The "Marvel" is more nearly like the "Magnus" in form of fruit but differs from it in the color, while the foliage is not unlike the "Ponderosa." In short, in the cross under consideration, the unit character to be considered is fruit color and not type of foliage. The "Magnerosa" has a lingering outcropping of coarse-leaved plants with constant fruit color, while the present cross has the leaf type uniform with pink fruits appearing occasionally in the selected red strain.

The results of the "Marvel-Ponderosa" cross were so satisfactory last season that seeds were selected and several rows of the following combinations were grown the present year: (1) 103/77; (2) 103/77//77; (3) 77//103/77, and (4) 103/77//103. The

first is a cross of "Ponderosa" (103) upon "Marvel" (77) represented by the fraction 103/77, that is, using the record number of the male parent as the numerator and of the mother as the denominator. The second combination is a result of the cross used as the male upon the "Marvel," the double parallel separating the parents in this union. The third is a cross of "Marvel" upon the original cross, and is styled a reciprocal of the previous (2) combination. The fourth is a union of the original cross with the "Ponderosa" as the female. The reader, from the position of the record numbers and the single and double lines, may quickly note the way in which the subsequent breeding of the "Magnus" and "Ponderosa" has been pursued.

A glance at the fruit sections in Plate VI. will help still further to give an idea of the fruits under consideration. The "slice" at 1 is of the primary cross as the fraction shows—which is upon a card, an inch square, to serve as a measure of the fruit slice. The endeavor was to select, as nearly as possible, an average typical fruit, but the photographing was unavoidably delayed until late in the season and the best fruits were all gone. The section at 1 is seen to be very "meaty," a strong characteristic of the "Ponderosa," and the seed cavities are much broken up and the seeds comparatively few. The fruit, as a whole, is a great improvement upon the "Ponderosa" because, with a much longer polar axis and therefore admitting of more slices, it is more nearly a circle in outline and but little grooved or ridged. This cross gives fruits that ripen quite early but the green shoulder is somewhat in evidence in otherwise mature tomatoes, suggesting the great defect of the "Ponderosa." The color is a pleasing red, but, if desired, a pink with all other qualities in common with the red may be easily secured and seeds in quantity of the pink-fruited strain have been secured.

At 2 is shown a section of a fruit of the second cross, as indicated by the fraction. This combination secures a medium-sized, smooth, apple-shaped tomato with the center less broken than in the original cross. The reciprocal of the last, shown at 3, produces a fruit of satisfactory size, form and smoothness with the wall thick and the interior thoroughly broken up and the red color uniformly distributed throughout the whole fruit.

By breeding the original cross, shown at 1, to the "Ponderosa" parent, a form of fruit is obtained that is not as desirable as in

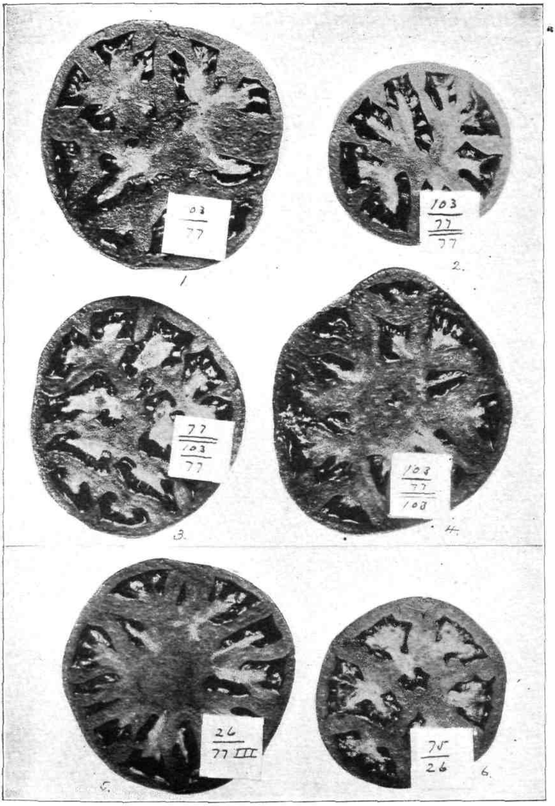


PLATE VI

the original cross because of the accentuation of undesirable qualities. A section of a fruit of this cross, which is three-quarters "Ponderosa," is shown at 4, and while the flatness is not evident in this view something may be seen of the irregularity of outline of the tomato. The center of the fruit is very fleshy and the area of seed cavity is correspondingly small. A three-quarter blood of the "Marvel" makes a more desirable fruit as to general form and size and evenness of ripening, and of this combination the one shown at 3 seems to be the nearest to the ideal, but of course, not attaining to it.

Reports from Testers of "Marvelosa" Tomato.

The seeds of this cross, 103/77, now named "Marvelosa" by combining the names of the two parents, were distributed as "Station Tomato No. 5" to thirty-nine applicants. From the reports submitted, the following extracts are given: "The plant is very strong and healthy, bearing good-sized fruit, smooth and perfect in shape and of a rich scarlet color." "Medium-size but very few small ones, a great bearer, very vigorous grower, no blight of any kind, shape round, color beautiful red when ripe, best of flavor and very fleshy; has very few seeds, one of the best for family use we ever raised; the soil in this place is none too good for tomatoes, but this one was fine." "Your tomato I think is fine, it is about the best I have ever grown." "Flavor excellent." "'Tomato No. 5' we found very good, large, deep red; one measured sixteen inches in circumference; very prolific bearer; am more than pleased." "Tomato has shown a strong, vigorous growth throughout the season; the tomatoes are of good size, smooth and of excellent quality; I think they would be an excellent market variety." "Plants vigorous, beautiful color, excellent flavor, thin skin without tough core." "Plants very vigorous." "'Tomato No. 5' proved worthy, was a good bearer, large size, had large seed cells; it may be classed as of good quality and a desirable acquisition." "Very productive and very solid and very delicious; the best we ever had." "The best of all the lot, large, perfectly smooth, vigorous, productive, an all-around grand tomato." "Each plant yielded from twenty-seven to thirty-two fruits each, uniform in shape and color; the height of each plant was about three feet and very stocky; the only fault about the fruit is that there is a hard substance in each fruit, otherwise they are perfect."

"Station No. 1."—"Arcadia-Earliana" (4/34).

A set of plants of the above cross was grown upon the Hon Grounds and it proved to be quite satisfactory. The note boc records the following facts: "Upon the 21st of June, the plan were in bloom; July 31st, very fine, large, red, smooth fruits wit very little inclination to crack. Prolific—seed saved. Augu 22d, nearly gone. Medium early." There is a further note t the effect that the fruits are superior.

The seeds of this cross were sent to forty-six applicants, fro whom the following observations have been received: "A prolif bearer and early, of a light red color, splendid flavor, all of uniform size, plants are hearty and strong." "Season secon early; it is a good general tomato." "Plants of 'Tomato No. 1' ar vigorous and productive and of good quality." "Extra goo shape." "I have had some very fine fruit from them and thin them of merit; I think they are an all right stock." "They are very fine tomato, the plant is of upright growth and a very vigo ous grower, having as high as thirty to thirty-five fruits to a pla of delicious flavor with few seeds." "'Tomato No. 1' had an exce tionally heavy crop; the vines were comparatively small but se heavily with fruit of good size and very uniform; flesh quit firm."

"Station No. 2"—"Arcadia-Cumberland" (4/28).

The set of plants of the above cross in the Gardens gave onl medium quality of plants, that is, too small and feeble and, ther fore, so far as this year's test is concerned not favorable.

Reports from those who had seed for testing run as follow "'Tomato No. 2' is very productive and very vigorous and fo size it will be very hard to beat, in fact, it is the best I have re ceived." "'Station No. 2' tomato is a very fine one in every wa in fact, I have not seen anything in the way of tomatoes that so uniform. It is a fine tomato and, by good treatment, will grac anyone's garden." "Am well pleased with this tomato; not in clined to rot as some other varieties." "Large size and health vine." "Very nice for table use."

"Station No. 3"—"Magnus-Crimson Cushion" (75/26).

The fifteen plants of the above cross in the Gardens were of arge size and great vigor and showed the two types of foliage as xpected, that is, fine-leaved and coarse-leaved in the seed flats and ome of each type were set. There was also a representation of etter colors of fruit, also expected, but not detectable until maurity was reached. In size and shape, the fruits are quite deirable and the vigor of the vines and their productiveness make his cross very promising for medium crop. The general strucure of the interior of the tomato is shown at 6 in Plate VI., but n this case the fruit is under size and is shown in company with ections of those that are somewhat larger than the market demands.

Out of this cross, four strains may be obtained because of the wo types of foliage and also of colors of fruits which entered into he combination.

The reports from the twenty-two testers are as follows: "Large nd strength good, is very productive and the uniformity is good." 'Plants are vigorous and productive and of fair size." "Good uality." "Fine quality and the nicest tomato we have had yet." 'Very fine plants and sweet to eat like peaches."

"Station No. 4"—"Crimson Cushion-Marvel" (26/77).

The good results of the previous year with the above cross were epeated upon the Home Grounds during the present season. Upon June 28th the record book shows: "Large, fine plants," and later n, from time to time, the notes show only words of commendaion. At 5, Plate VI., is shown a section of fruit of the third eneration. Its center is a solid flesh of satisfactory texture and olor. This is an improvement on the "Crimson Cushion," which s apt to be irregular and always too flat, approaching the serious lefects of the "Ponderosa" among the red-fruited sorts. By breedng the "Marvel" to this cross, fruits are obtained in which the olid pulp center is broken and numerous seed cavities are scattered hroughout the tomato. At the same time, the fruit is elongated, hat is, its flatness overcome with some loss in size. This cross,

as it combines so much of vigor and fruitfulness, is full of promise for a medium crop.

The seeds were distributed to fifteen applicants, some of whom have reported as follows: "Good healthy plants, yielding a good crop, medium early, believe they would do well in this section." "Vigorous grower and my plants are very heavily loaded with large-sized fruit." "Produced fine large fruits." "This tomato proved very successful and of very fine flavor."

"Earliana-South Jersey" (33/119).

In point of earliness, nothing among the crosses has been superior to the combination between "Earliana" and "South Jersey," both low-spreading sorts with red fruits. Four rows of fine *plants were grown, namely, the "Earliana" upon "South Jersey"* for the first and second generations and the reciprocal for the same generations. The two parents are quite similar in earliness and in productiveness, the "South Jersey" being somewhat ahead of the "Earliana." The former produces a large, flattish fruit that is not as smooth as the "Earliana," but ripens more evenly. The four rows were all nearly alike in characteristics, and therefore they did not furnish any clue as to the most desirable combination of the parents. They also indicated that no great variation might be expected in later generations. Seed was saved and some of it may be offered for testing, while a further trial is anticipated upon the Home Grounds.

"Bright and Early-Nolt's Earliest" (14/94).

The first and second generation of the above cross was grown with the result that the plants came early into bearing and the fruits were of fine shape and color but not quite large enough for the general trucker. For home use, where a medium-sized, bright red, "apple"-shaped fruit is desired, this cross would be acceptable, and for forcing it would seem to leave but little to be desired.

"**Fortune-Earliana**" (53/33).

The "Fortune" is a variety that has made a good record in its crosses for the past two years. The plants, as a rule, are large and strong and medium as to time of bearing the crop. A combination with the "Earliana," in which "Fortune" is crossed upon the hybrid of "Earliana," is shown at 1 in Plate VII. It is seen that the interior is quite solid and yet is somewhat broken by the seed cavities. The wall is of good thickness and the fruit is large enough, as indicated by the label (an inch square) bearing the record numerals of the kind and character of the cross. There was some variation among the plants as to the smoothness of the fruit and seed was saved only from the most desirable.

"**Giant-Ponderosa**" (56/103).

The cross between the two varieties named above, as expected, gave very large, long vines and fruits undesirably large and irregular. The notes show that the fruits were an improvement upon the "Ponderosa," but the only excuse for growing this cross would be that of a desire to see how large a crop could be produced. The ground, late in the season, was literally covered with the enormous misshapen fruits. The first of the two fruits of this cross, shown in sectional view at 2, is of the second generation as indicated by the Roman numerals upon the label, while the next slice-view (3) is of a specially selected plant (*c*) of the previous year. The second varies somewhat from the first in having the large center less broken by small seed cavities. It is not unlikely that this cross will be useful in breeding for solidity and comparative seedlessness, but, in itself, it is not desirable except for an enormous crop.

"**Honor Bright-Fortune**" (60/53).

Somewhat similar to the fruit of the "Fortune-Earliana" is the one in slice-view shown at 4, where, as shown by the label, the "blood" of the "Fortune" makes up three-quarters of the whole. The five plants were all stout, showing none of the yellow foliage common to the "Honor Bright" and bore a large, late crop of red,

flattish fruits. In this cross, the seed cavities are large as compared with the cross last described but superior to it in length and smoothness as well as color of the fruit.

"Magnerosa" (75/103).

A fair sample of this new variety of Station tomato is added here (5) by way of comparison and to show an average fruit in its third generation upon the Home Grounds. The broken center is well shown in the section, as also the thickness of the wall and number and size of the seed cavities.

"Magnerosa" upon "Aristocrat-Extra Early Tree" (75/103//171/159).

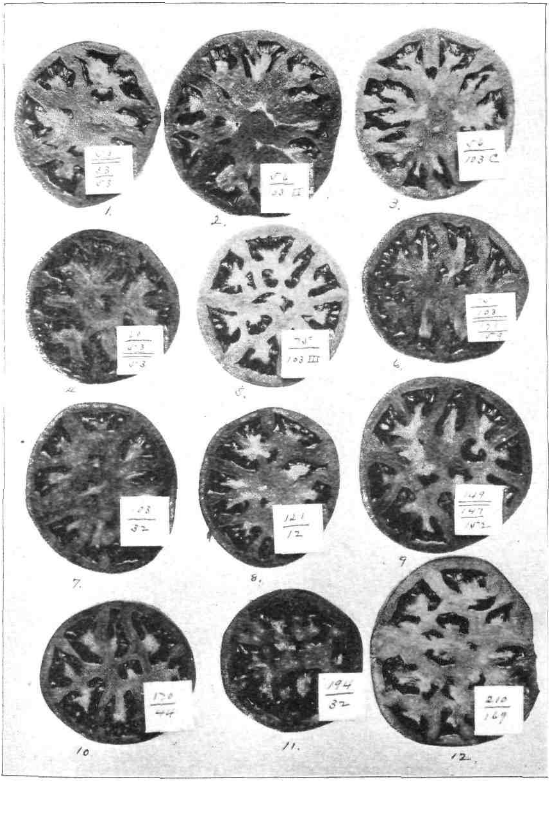
By combining the "Magnerosa" with a cross of "Aristocrat" upon "Extra Early Tree," a set of plants was obtained showing much variability. The fruits were large but too irregular (6) and, coming late in the season, were not especially desirable. It remains to determine what careful selection may be able to bring out and fix in this combination. The breeding together of more than two varieties is usually a loss of time and trying to the patience.

"Ponderosa-Duke of York" (103/32).

Two rows of the cross of "Ponderosa" upon "Duke of York" were grown the present season and all the plants were of large size and produced much fruit during the middle of the season. The tomatoes were too large and irregular for the market. The flesh was of a fine pink color and the small seed cavities were scattered through the center, making a solid fruit (7). It is likely that, by breeding, the undesirable features may be removed and a fine variety secured.

"Stone-Best of All" (121/12).

At 8 is shown a slice-view of the above cross, which is not an entirely satisfactory fruit because of its medium small size. There were, however, some very superior tomatoes and somewhat earlier than the "Stone." The color was a very desirable bright red. By selection for greater size this cross may prove acceptable.


1.
2.
3.
5.
6.
7.
8.
9
10
11.
12.
121/12
170/44
194/32
210/169

"Aristocrat-Lemon Blush" (149/147).

The above cross is between a red-fruited dwarf ("Aristocrat") and a yellow standard sort. Only the standard plants were selected from the seed bed for setting in the field. The "Lemon Blush" is remarkable for its great vigor and healthfulness of vines. The five plants all chanced to be red-fruited and, therefore, as to type of plant, standard and color of fruit, there was uniformity. The row was a good one and the fruit section shown at 9 is a fair sample of the whole and presents to view a well disposed center and a thick wall, while in shape it leaves but little to be desired.

"Dwarf Stone-Enormous" (170/44).

Upon "Visitor's Day" (August 17th), when several hundred persons interested in crop-growing viewed the Garden, there was no row of plants that received more favorable comment than that of the "Dwarf Stone" upon the "Enormous." Many other crosses were past their prime but this was at its best. The plants were all of the standard type, the dwarfs (about one-fourth in all such crosses) having been discarded when the others were removed from the seed bed. Perhaps the leading feature of attraction was the fine bright red color of the fruits, combined with satisfactory size and smoothness. The center of one of the fruits is shown at 10 and it is seen to lack somewhat in solidity, but there is an entire absence of any hard green core, so objectionable in some varieties. It is too soon to judge of the merits of this cross but it may be offered for a general test. Of course it is not an early tomato.

"Globe-Duke of York" (194/32).

The "Globe"—a novelty sent out in 1905—was bred to several varieties last year and these crosses have been studied the present season. A fruit slide of the above cross is shown at 11, but it does not do full justice to the cross because of lack of fruit when the photograph was taken. The "Globe," as the name suggests, has a fruit with a long polar axis and the combination with the "Duke of York" did not materially improve the center. In vigor and

productiveness of plant, the cross is satisfactory and the color, following both plants, is of course a pink. There were other crosses with the "Globe" that give more of promise.

"Station Yellow-Dwarf Stone" (210/169).

Only two plants were grown of this cross, both of which were dwarf, following the parents—but in color of fruit one was yellow and the other red. The tomatoes, aside from color, were alike and quite satisfactory—the interior being a blending of flesh and small seed cavities, as shown at 12 in Plate VII.

Some of the "Globe" Crosses.

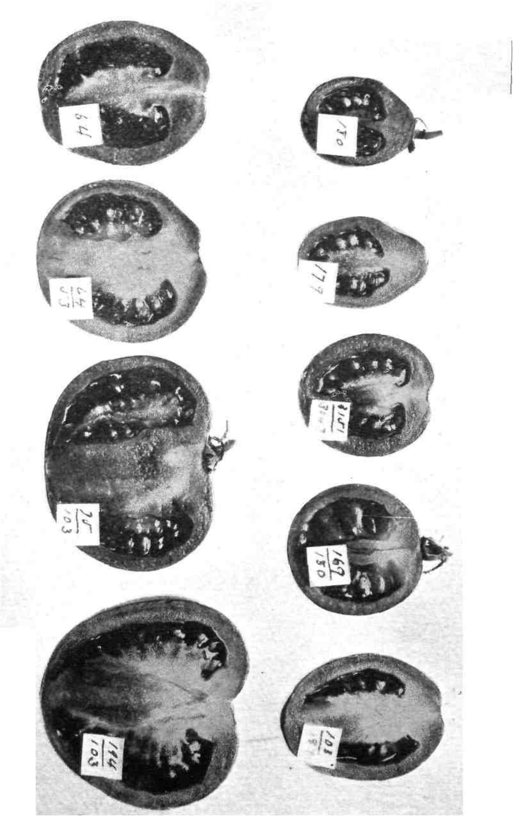
The "Globe" was crossed upon the following varieties last year: "Brinton's Best," "Duke of York," "Imperial," "King Humbert," "Magnus," "Ponderosa" and "Alice Roosevelt." This block of crosses, with the male parent in common, gave promises of results that will be announced later. With the exception of the "Duke of York," all the crosses were grown for the first generation in the greenhouse and, therefore, in the field the past season the first and second generations were grown side by side in parallel rows.

The "Globe-Brinton's Best" (194/15) cross for the first generation gave long vines, four of which bore red, and one pink, fruits. In the second generation, the plants were practically the same, namely, two with red and three with pink fruits. Out of this cross, there may be two strains separated, upon the basis of fruit color. The fruits were long, to which the term "apple-shaped" is temporarily applied.

The "Globe-Imperial" (194/63) gave three red and two pink fruited plants for both the first and second generations. Here the vines showed much length, were prolific and the fruits solid "apple-shaped" and somewhat late in maturing.

In the "Globe-King Humbert" (194/64) cross, the fruits were a very long plum in both generations, not easily distinguished and all were red.

The "Globe-Magnus" (194/75) cross gave strong plants, only the fine-leaved type being grown and the long fruits were all of the pink color.



A variable set of strong plants was produced in the "Globe-Ponderosa" (194/103) cross and here the shapes of the fruits were full of interest. Some were flattish and rough like the "Ponderosa" parent, while others were "apple-shaped." A longitudinal section of one of the tomatoes, showing considerable length of axis, is seen at 9 in Plate VIII. In this plate, the label is a half-inch square and several examples of tomatoes with a long polar axis are given, as follows: 1, "Red Plum" (180); 2, "Red Pear" (179); 3, a cross between two long-fruited kinds from Italy (3151/3047); 4, "Dwarf Stone" upon "Red Plum" (169/180); 5, "Ponderosa" upon "Sumatra Fig" (103/181); 6, "King Humbert" (64); 7, "King Humbert" upon "Fortune" (64/53); 8, "Magnerosa" (75/103), and 9, "Globe" upon "Ponderosa" (194/103), mentioned above.

"Red Currant-Dwarf Champion" (177/154).

The above cross is a very violent one because it is between two species, the "Currant" and the common type of tomato, and, secondly, the former is a standard of a very fine-leaved group while the latter is a dwarf. The blend resulting from the cross was grown in the greenhouse and from seed of this the twenty plants were raised, from which selections were made for the types shown in Plate IX. The spray, shown at 1, might be mistaken for the true "Currant," but upon close inspection, there are sufficient evidences of the cross. At 2 the foliage is seen to be approaching that of the ordinary standard fine-leaved type. Through 3 the type changes somewhat abruptly in 4, in which the stems are upright for a time and afterwards bend over clumsily because of the great length of the stems of these crosses. The leaves are, perhaps, the most different from the ordinary "Currant" type, they being short with the divisions broadened and strongly curled downward and inward. The extreme type of the crosses is seen at 5, in which the foliage of the mother plant is most nearly approached. These plants, four out of the thirty, were nearly upright, comparatively, short-stemmed and may be classed as dwarfs although the axis of the plant is longer than a dwarf of the common sorts of tomatoes.

In fruit the variations were not great, all plants producing clusters somewhat after the "Currant" type, but shorter, with the

tomatoes of the size of large cherries. It was observed that some plants produced fruits that averaged larger than those of others, while six were pink, following the "Dwarf Champion" parent, and the other fourteen were red, like the "Currant."

There is, perhaps, but little of practical value in the results of this cross. The dwarf forms may serve as useful plants for producing small, neat fruits in great abundance for pickling or where a small, round tomato may be of special use. Seed by inbreeding was obtained from these plants.

It was observed that the flea-beetles, and possibly other insects, were more apt to eat the foliage of these crosses than that of the ordinary sorts.

Narrow-Leaved Tomato Plants.

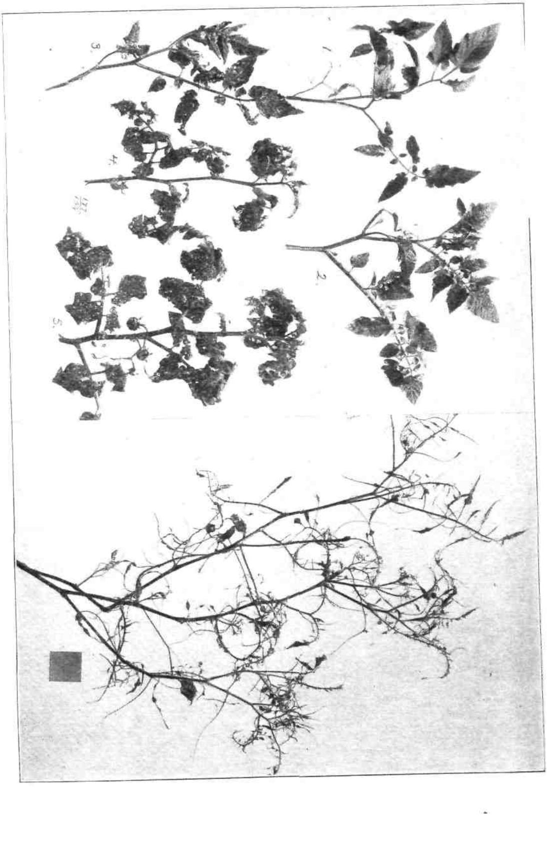
Several plants of the "filiform" type of foliage were found among the crosses the present season. These agree, in general, with those that were first noticed the previous year and noted in the Report (1905) upon page 472. These plants are peculiar in having the expansions of the leaves reduced to narrow threads, not much more than the main veins remaining. The general appearance of a spray of a filiform plant is shown upon the right side in Plate IX. Frequently the terminal portion of the leaf is broader than any other similar portion, giving a strange aspect to the plant. The flowers partake of the slender, elongated nature of the foliage, and are therefore somewhat longer and very much narrower in the envelopes than the common blossoms. They form the most striking variation that has been observed in tomato flowers, which, as a rule, are quite constant.

The plants showing this type of leaf are not fruitful, and do not seem to be of any practical use. Seeds have been obtained from inbred plants that the peculiarity may be further studied as to its persistence and effect when bred with the ordinary kinds.

TOMATO PLANTS FROM CUTTINGS.

Cuttings were taken from several of the most acceptable tomato plants that were grown in the greenhouse and placed in the garden. The following is the list, with occasional comment:

"Atlantic Prize-Washington" (7/212) gave one plant, not thrifty.



1.
2.
3.
4.
5.

"Beauty-Fortune" (8/53) gave fine, high-colored (red), uniform fruits.

"Bright and Early-Nolt's Earliest" (14/94). The fruits were uniform upon all the plants, but a trifle too small for field culture.

"Cumberland-Dandy Dwarf" (28/158). The foliage of these plants was of the yellow type, and strengthened the opinion that it is not as good as the ordinary green kind.

"Earliana-Jewel" (33/66). This proved undesirable because of undersized fruits that cracked.

"Giant-Ponderosa" (56/103). Here the plants and fruits were all of the same type, but the latter were too large and irregular.

"Giant-Globe" (54/194) produced a large number of large fruits, but late in the season.

"King Humbert-Fortune" (64/53). These plants, while uniform in all respects, showed too much of the "Humbert" blood to be of much value.

"King Humbert-Giant Climbing" (64/57). In itself, not worthy of culture.

"King Humbert-Ponderosa" (64/103). Very productive, but the fruits were long and flabby.

"King Humbert-Lemon Blush" (64/147). Undesirable, but may be of value as a breeder.

"Magnus-Crimson Cushion" (75/26). A fine set of plants, uniform in all respects. This meritorious cross is reported elsewhere.

"Magnus-Earliana" (75/33). This gave uniformity in vine and fruit, the latter being of desirable form and color.

"Magnus-Dwarf Champion" (75/153). This was a set of the dwarf type of uniform character and excellence.

"Magnus-Dandy Dwarf" (75/158). The green foliage type of plants was represented and proved of only fair fruitfulness.

"Magnus-Alice Roosevelt" (75/188). This cross, throughout the cuttings, grew uniformly strong plants with "apple-shaped" fruits.

"Ponderosa-Duke of York" (103/32). The plants were uniformly large-sized but the fruits lacked desirable qualities.

"Potato Leaf-Minnesota" (104/87). The fruits were too small for field culture.

"South Jersey-Bright and Early" (119/14). The plants were medium and the fruits fair, red and smooth.

"South Jersey-Earliana" (119/33). The plants did well and the crop was early and satisfactory.

"Stone-Brinton's Best" (121/15). This even set of plants gave fine large fruits.

"Dwarf Stone-Imperial" (170/63). The plants were all poor.

"Dwarf Stone-Golden Queen" (170/144). The uniform plants were strong, of the standard type with very firm, bright red fruits.

"Alice Roosevelt-Imperial" (188/63). This was a poor set of plants.

"Globe-Brinton's Best" (194/15). This gave a set of plants with red, smooth fruits.

"Globe-Duke of York" (194/32). The fruits were large, pink, "apple-shaped," but not regular.

"Globe-King Humbert" (194/64). This gave a long, flabby fruit.

"Globe-Magnus" (194/75). A set of strong plants, all fine-leaved and pink-fruited.

This experiment strengthens the belief that blocks of tomato plants may be easily obtained from cuttings that will be extremely uniform, and, until varieties are more stable than at present, it may be desirable to thus secure fancy crops of the very choicest types of plants of any selected kind. It is a treat to the grower to be able to fill his baskets or wagons with fruits that vary no more than do those from any one plant that approaches the ideal tomato.

The fact of nearly absolute uniformity in shape and color and approximately so in size is one that appeals to some truckers, as it does strongly to the fastidious consumer, and, through the method of making cuttings, the way is clear to an increased pleasure, if not of profit, in tomato growing.

GENERAL REMARKS UPON TOMATO EXPERIMENTS.

There were two hundred and eighty-four crosses, five plants each (with few exceptions), grown the present season, not including thirty-six crosses from cuttings taken from the greenhouse plants. Representatives were in quantity of standard and dwarf types of plants; fine, coarse and yellow sorts of foliage; red, pink, yellow and "white," smooth and hairy (fuzz) fruits.

The standard plants have, as a rule, done better, but perhaps in a soil more congenial to tomatoes the dwarfs might be as preferable. The latter, being smaller, may be planted much closer and permit of horse tillage where the standards spread and interfere with the cultivator or plow. Certain of the dwarfs did remarkably well, giving some of the finest fruits that were grown. The test, in continuation of the "Magnerosa-Dwarf Champion" (75/153) crosses, offered an opportunity to study the subject of size and type of foliage at the same time. Rows were set with plants of the following four possible combinations: (1) standard fine-leaved; (2) standard coarse-leaved; (3) dwarf fine-leaved and (4) dwarf coarse-leaved. The rows were side by side, and, as far as possible, the same conditions prevailed with all plants as to time of seed-sowing, transplanting and field culture. The dwarfs were given the same ground space as the standards, which was to their advantage. Under the above-named circumstances, the general conclusion was that the standard fine-leaved plants were superior and the relative merit of each of the four groups is expressed by the order in which they are given above. This corresponds with the report of the same test made last season, and therefore one year earlier in the history of the development of these four types from the single mother fruit. Where the dwarfs are set a half more to the acre than the standards, it is likely that the yield will equal that of the standards for any given area. The fruits upon the dwarfs vary less in size than upon the standard plants, that is, they are neither as large nor as small, and in this respect are superior. Again, the dwarfs are more apt to bear the fruits up from the ground, and are therefore more perfect in exterior and somewhat better flavored. When a dwarf "falls over," it makes a one-sided plant that is much less shapely than the standard and more apt to get broken off near the root. A single stout stake would help to hold a dwarf in place much better than a standard that is not pruned to a single stem, in which case the latter would become tall and troublesome.

The yellow foliage was more or less in evidence in nearly all the crosses where it is a parental characteristic. In a double combination of "Honor Bright" (with yellow foliage) and "Fortune" upon "Fortune," in which, therefore, the "Honor Bright" is represented by one-quarter, there were no yellow-leaved plants among the five of the row. But in the cross of "Honor Bright" with

"Frogmore," there was one of the "sickly" yellow plants to four of the usual green type. Among the "Princess" crosses, comprising twenty-two plants, there was only one that showed the peculiar foliage in question, but this one was strongly marked and indicates that the characteristic may be expected to appear in small numbers for an indefinite time in crosses where one parent is "yellow-leaved."

Concerning the color of the fruit, it is not easy to state the results of the observations in a few words. The reds, pinks and yellows are fairly constant, and all attempts to develop intermediates have been failures, excepting that, for example, the "reds," so-called—which are, in fact, a dark orange mixed with red—have in some instances lost all of the red and developed pure orange fruits. Seeds from these orange fruits do not give fruits after their kind, but the old mixture of colors. When the "reds" and "pinks"—which differ from the "reds" in having less orange—are bred together, the offspring are easily arranged under the two parental colors, one-fourth being "pinks." Here, again, there are slight modifications.

With the yellow color there is more hope of getting a combination with the reds and the striving after a deep blush upon a yellow background, like a peach in its perfection of color, may not be in vain.

The so-called "white"-fruited sorts have been grown only to a limited extent, and the crosses obtained are few. Thus the "Ivory Ball," in combination with "Duke of York" (32/175), in its second generation, gave three plants with pink fruits, like the male parent, and two with very pale yellow fruits, styled "whitish lemon" in the note-book record. This last is quite different from the mother fruit, which does not show the yellow. A similar result was obtained with the "Aristocrat," three of the plants giving light yellow fruits, while two were red, but, most interesting of all, showing the yellow as blotches upon the surface. When the "Gold Ball" is bred with "Ivory Ball" (172/175) there results in the first generation a fruit that is of a lighter yellow than the male. In the next generation the same lighter color is retained as a constant average between the two parents. In the cross with "Yellow Cherry," the "Ivory Ball" (175/183) produced a pale yellow fruit of the size of the "plum," and again reduced the amount of yellow

in the fruits. The same peculiar lemon color was uniformly retained in the next generation.

Nothing has been done directly to study the peculiar fruit coat that is characteristic of the peach. In the cross of the "1903" with the "Quarter Century" (143//165/143) the "peach" surface was apparent upon the tomatoes of four out of five plants, and in this respect followed the male. It should be said that the "1903" blood in this instance is represented by the fraction 3/4. The results of previous observations lead to the opinion that the fine hairiness upon the fruit is not expected upon more than a quarter of the plants in the first generation, after the blend, when one parent has that characteristic.

EXPERIMENTS WITH EGGPLANTS.

During the present season, the area devoted to eggplants has been chiefly occupied with crosses between the several varieties, and, necessarily, but little space was given to the parent sorts. A comparatively full list of the commercial varieties that have been grown, with partial descriptions of the same, are given in the Report for 1905, pages 485-492. There were only a few representatives of the "Jersey Belle" upon the Home Grounds. Packets of the seed of this sort were distributed in the winter to two hundred and twenty-six (226) applicants, nearly all within the State, and from their reports the following extracts are made.*

Reports upon the "Jersey Belle" Eggplant.

"This eggplant is very large and productive for an early sort, good purple color, well shaped, some slight variation as to type." "Would say my 'Jersey Belle' eggplants are the finest I or any of my neighbors ever saw. They stand three and four feet high, and are very bushy. The stems are a very dark purple, also the fruit. I picked my first the twenty-first of July and it measured twenty-three inches around and twenty-six the long way. They are per-

*Seedling eggplants are not as easy to grow as young cabbage plants, or even tomatoes, and this seems to be the reason for the failures, in some instances, to secure satisfactory plants. If the trial of these seeds has led growers to look more carefully to details in such matters in the future, the results marked failures will not be altogether without fruit.

fectly smooth, and some plants have seven and eight on them." "They are good bearers." "Plants vigorous, some stocky, others of taller growth." "All are of good quality." "Free from disease." "The seed I received produced very large eggplants of good purple color and well shaped." "Two or three fruits on all plants." "The fruit is of good shape and size for slicing." "The plants are large, stocky and vigorous, and the leaves dark. The fruit varies from long to half-long, quality the best. I consider it worthy of general cultivation." "I think it a variety worth keeping, as they started easily when little plants." "It has met all one could expect, and at the present time is doing nicely; the size is good, and it is very productive; we have never had such very good success with eggplants, but this is as good or better than we have ever had before." "Color very fine." "The 'Jersey Belle' is doing finely; a quick, vigorous grower, setting fruit nicely; earlier than the 'New York Improved,' set at same time; I think it a very promising variety." "The eggplant has continued to bear fruit liberally, some being quite long, others similar to 'New York Improved;' it is a very desirable sort, being earlier with me than any other I have." "It is thirty-three to thirty-seven inches in height; vigorous grower; three to six fruits at once, with crowded blossoms all over plant." "We are much pleased with the 'Jersey Belle;' we are growing the 'New York Improved,' and I notice the superior shape of your plant, it being more of an ideal shape for slicing; it seems to be a hardy, vigorous grower, and we hope to produce more of its kind next year." "I succeeded in raising fine plants; the fruit is five to six inches long, three to four inches thick, and one plant has three of this size and five smaller ones." "The 'Jersey Belle' eggplant is growing finely; in the bed from the seed you sent me there will be a reversion to the parent stock of about 20 per cent., largely of the long purple variety; the true type, however, will be attractive in appearance and a fine grower; color, dark purple; very quick in maturing its fruits; I am inclined to think it will be the earliest of the large varieties; plant a vigorous grower, and about as productive as 'New York Improved.'" "The 'Jersey Belle' is an entire success; the plants are about two feet high and very vigorous; they are loaded with fruits and blossoms; plants very uniform in shape; fruits exceedingly fine." "The eggplant is satisfactory; it is a vigorous grower and has large

fruits; flavor good." "Flavor of fruit unusually good; better than the large variety I have." "A good plant and a good bearer."

The crosses considered below are arranged in the sequence of the numerals representing the male parents.

"Black Snake" upon "Dwarf Purple"–(2/5).

Of this cross seventeen plants were grown and all were thrifty and in full bloom by the middle of June. Later on, July 14th, it was noted that the plants were of medium height and full of fruit, showing that this cross is early and the plants are comparatively small. The record shows that eleven of the plants were decidedly dwarf while others were of nearly the standard size. All had purple foliage and stems with the same color for the fruits, which were long, pear-shaped and too small for the summer market. It was also recorded that the fruits did not decay as is the case with all of the more common sorts. An inferior sample of the quite uniform fruit of this cross is shown at 1 in Figure 1. As the photograph was taken very late in the season, the sample is not up to the average for this cross.

"Black Snake" upon "Early Dwarf Oval"–(2/6).

This cross gave a set of thirteen plants that were similar in all respects to the cross previously mentioned. Four plants were dwarfs and nine of the standard type. Fruits were produced early, as previously stated, and in very great abundance, held on without decaying throughout the season, but, unfortunately, are too small for the market unless they may be of particular value when grown in the greenhouse for winter use.

"Black Snake" upon "New York Improved"–(2/18).

This cross was represented by five plants, all of upright growth and with dark foliage representing two types, namely, those that were very tall and decidedly bushy and the dwarf type, there being three of the latter. The tall plants were fairly prolific and the dark purple fruit resembled the male parent in being quite long.

"Black Pekin" upon "Black Snake"—(3/2).

Nine plants of this cross were grown and they showed both parents in the tallness of the plants and the dark foliage and stems. All the plants came into bearing early and were comparatively *fruitful. The fruits themselves were not large,* quite elongated, somewhat curved and combined the characteristics of the two parents. A sample is shown at 2 in the engraving.

"Dwarf Purple" upon "Black Beauty"—(5/4).

There were ten plants of this cross, all of them large and excellent. Fine marketable fruits were in abundance on July 14th and were quite uniformly of the oval type shown at 3 in the engraving. There was a tendency on the part of the plants to break up into two types as to size, half being strictly standards and the other five of a more dwarfish nature. The foliage was unusually strong, the leaves being broad and green, as also were the stems. This is a *promising cross.*

"Dwarf Purple" upon "New York Improved"—(6/19.)

This *cross showed strongly* the blood of the "Dwarf Purple," giving a set of low, spreading plants with purplish foliage and stems. The fruit, of good size and produced in abundance, was of a handsome pear-shape, as shown at 4.

"Jersey Belle" upon "Black Snake"—(10/2).

This cross was represented by thirteen plants, all of them quite tall like the "Black Snake," with dark foliage and stems. The fruits were produced in abundance and had a long, cylindrical form, shown at 5, and varied as to the color, some of them being of a rich purple while others were inclined to be green and somewhat striped, as indicated in the engraving. This type of fruit is quite close to that of the "Station Eggplant No. 1," seed of which was distributed to a limited number at the beginning of the season.

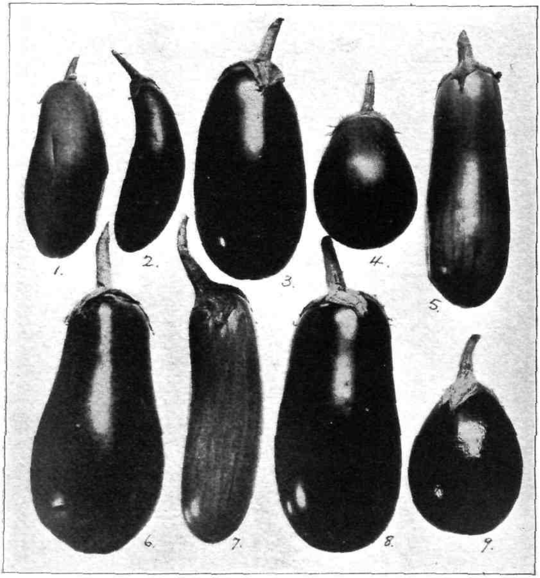


Fig. 1.

Crossed Eggplants. "Black Snake-Dwarf Purple" is shown at 1; "Black Pekin-Black Snake," 2; "Dwarf Purple-Black Beauty," 3; "Dwarf Purple-New York Improved," 4; "Jersey Belle Black Snake," 5; "Jersey Belle-Excelsior Tree," 6; "Long White-Black Snake," 7; "Long White-Black Beauty," 8; "Pride of Sunnyside-Black Beauty," 9.

PLATE X.

Eggplants. Two plants of the Hybrids between "American" and "Chinese" Eggplants; the one upon the left is large and barren, and the right hand one is dwarfed and loaded down with the small, nearly smooth, fruits.

"Jersey Belle" upon "Excelsior Tree"—(10/7).

Only five plants of this cross were grown the present season, two of them being of the standard type with broad leaves showing, but little purple color in the stems and the fruits of particularly attractive form, a long bell with a rich purple color; the record book has underscored against this type of this cross the word "promising." A representative of the fruit is given at 6.

"Long White" upon "Black Snake"—(11/2).

There were ten plants of this cross and all of them were tall with purple in both leaves and stems. The long, cylindrical fruits were seasonable, some of them purple and others decidedly green, somewhat striped and turning yellow when ripe. The specimen shown at 7 gives some idea of the marking upon the fruit above mentioned. The plants of this cross were particularly noticeable because of their extra height and the long, slender fruits, borne in considerable numbers and which are particularly adapted for slicing.

"Long White" upon "Black Beauty"—(11/4).

Eleven very fine, thrifty plants of this cross were grown and attracted much attention on account of the large size and fine form and coloring of the fruits (8) which they produced. All the plants were green throughout in stem and foliage, of medium height, came into bearing promptly and held out through the long season, giving great promise for this combination. It is noted that the blend represented by this set of plants showed nothing of the color of the white parent, the fruits being of a particularly rich dark purple.

"Pride of Sunnyside" upon "Black Beauty"—(20/4).

The thirteen plants representing this cross were all of small size, rather broad-leaved, with purple color and foliage, and younger branches late in coming into bearing and not very fruitful. A sample of the fruit is shown at 9.

"Long White" upon "New York Improved"—(11/18).

In 1905 the third generation of this cross was represented by a block of thirty plants, as recorded in the Annual Report for last year. It was there stated that "seeds were saved from only two plants, and these were exceptionally fine in many respects, and agreed in having the many fruits—one seven and the other nine—of a delicate pink color when ready for the market." During the present season forty-five plants from the seed of the best plants above mentioned were grown in the Gardens. Upon July 9th the plants were in bloom and some variations were noted, and a week later it was observed that while some of the young fruits were a bright pink, others were entirely white. Later in the season it was determined by actual count that there were thirty-seven plants that bore pink and eight white fruits. The plants were quite uniform in size and character of foliage, with the leaves and stems of a strictly green color. The fruits themselves, borne in abundance, were long bell-shaped. The color varied among the pinks, some of them being dark and others decidedly light, so that further selection is much needed before a uniform fruit, in color and also in shape, is obtained. The type of plant, productiveness and desirable shape of the fruit all combine to make this cross one of decided promise. The small number of white throughout the plants suggests the Mendelian law, the pink color being dominant. In type of plant and productiveness, and in fact all other characteristics than the color, the white strain agrees with the pink sort above mentioned. Fruits were obtained by hand pollination, and there is hope of having a block of plants next year that will be entirely of the white strain. There remains one characteristic to be mentioned, namely, that the flesh of the fruit of this cross, whether pink-colored or white upon the surface, resembles that of the "snow" apple ("Fameuse"), and is decidedly attractive, giving this cross a characteristic that separates it readily from all other crosses grown in the Gardens.

HYBRID EGGPLANTS.

In 1904 a fruit was obtained upon the "Scarlet Chinese" eggplant (*Solanum integrifolium* Poir.), bearing seeds that were fertilized with the "Fordhook Improved" (*Solanum Melongena* L.).

This combination has taken the fractional record number, 14/25. Last season a single plant of the hybrid was grown, a description of which, with engraving of fruit sections, was given in last year's Report, pages 291-492. During the present season thirty-six plants, representing the first generation from the blend, were grown in the Gardens, a record of which, in tabular form, is given below:

Number of Plant.	SIZE.	COLOR.	FOLIAGE.	Spines.	Flowers.	Number of Fruits.
1	Tall	Green	Large, crinkled	None.	Few, white.	0
2	Medium	Purple	Small, smooth	"	Few, pink.	4
3	"	"	" "	"	" "	10
4	Small	"	Medium, crinkled	"	" "	3
5	Tall	Green	Large, crinkled	"	Few, white.	0
6	Large	Purple	Small, smooth	"	Few, pink.	4
7	Low	"	Medium, smooth	"	Many, pink.	0
8	Medium	Green	" "	"	Few.	3
9	"	Purple	Large, crinkled	"	"	12
10	Tall	"	" "	"	Few.	8
11	Dwarf	"	Small, smooth	"	"	3
12	Tall	"	Large, crinkled	"	"	7
13	Medium	"	Medium, crinkled	"	Few.	45
14	Low	Green	Large, smooth	"	"	12
15	"	Purple (light)	Medium, smooth	"	Medium.	3
16	Medium	Green	" "	"	"	5
17	"	Purple	Small, smooth	"	Few.	2
18	"	"	Medium, crinkled	"	"	9
19	Low	"	Long, crinkled	"	"	7
20	Dwarf	"	Medium, smooth	"	"	3
21	Medium	"	" medium	"	Medium.	20, small.
22	"	"	" "	"	Few.	3, very small.
23	"	Purple (Green)	" crinkled	"	"	2
24	"	" (dark)	Large, smooth	"	"	6, late.
25	Tall	" (Green)	" crinkled	"	"	5
26	"	Green	" smooth	"	"	3
27	Dwarf	Purple	Medium, smooth	"	"	30
28	Medium	"	Large, smooth	"	"	2
29	"	"	Medium, smooth	"	"	20
30	"	Green	Large, smooth	"	"	12
31	Dwarf	Purple	Small, smooth	Yes.	"	35
32	Tall	"	" crinkled	"	Medium.	30
33	Medium	"	Medium, smooth	"	"	40
34	"	"	" "	None.	"	4
35	Large	"	Large, smooth	"	Few.	5
36	"	"	" "	"	Medium.	0

The above table of the thirty-six plants, grown from seed from the single-blend plant of the previous season, shows several leading points in which the individuals differed from each other. The general terms as to size in the first column, when grouped, include the following number of plants: Large, 3; tall, 7; medium, 17; small, 1; low, 4; dwarf, 4. In other words, there were above medium, 10; medium, 17, and below medium, 9, or one-half were medium and one-quarter tall and the other quarter dwarfed. The record of color of stems and foliage shows that six were green, with three others with a combination of green and purple; that is, one-quarter showed green and three-quarters purple. The size and appearance of the leaves varied greatly, and do not admit of much grouping. There were 14 large, 15 medium and 7 small-leaved plants, and 22 with smooth leaves, 12 with crinkled foliage, and 2 that were midway between the two. There were only 3 of the plants with prickles or "spines."

The flowers varied somewhat in size, and those borne by purple plants were pink, while the green plants had white blossoms. As a rule, the flowers were numerous, but failed to set fruit. In this last point of fruitfulness there was a great range. There were four plants that produced no mature fruits, one of them being among the largest in the block. The four dwarfs gave an average of eighteen fruits, while the largest plant averaged only about three fruits. This condition of fruitfulness is well shown in Plate X., where a large and small plant are given, the former bearing no fruits and the latter thirty. The size, shape and color of the fruits upon any given plant were quite constant, but there were many variations upon the whole block. The fruits from the two parents are shown in the upper half of Plate XI., "American" at 1 and "Chinese" at 2, and sample fruit-bearing stems from ten hybrids are shown from 2 to 10, those at the left being more nearly smooth and most approaching the common garden parent. Many things are lost in the engraving, as, for example, color, which is uniformly orange, and therefore differing but little from the "Chinese" parent. The shade, however, varies, and in those fruits that are nearest "apple-shaped," as at 2 and 3, the color approaches lemon, and something like that taken on by certain garden eggplant fruits, as the "Dwarf Purple" when fully mature. The three fruits shown at 7 are larger than the "Chinese," but quite as flat, and

deeply ribbed and like it in color. Many plants produced fruits that constantly were much smaller than the "Chinese" parent, and one plant produced a liberal quantity of fruits, nearly all of which showed a long, conical projection at the blossom end, specimens of which are shown at 9. These instances go to show that in this, the *first generation after the blend, the "current," so to say, of the two* commingled "bloods" is not flowing evenly, and one cannot feel certain of anything until more generations are grown.

It is, however, apparent that in the matter of the character of the fruit, the "Chinese" exerts a preponderating influence over the "American," but it is to be remembered that the large size of the fruits of the latter is a cultural development, and, so far as affecting the hybrid, it may be that the small-fruited wild type might have been as effective.

The matter of the lack of "spines," with the exception of three plants, is one of special importance, in view of the fact that both *parents were "spiny," and, also, the blend plant that was grown* last season.

A Derivative "American-Chinese" Eggplant Hybrid.

In 1905, a combination was secured between the above hybrid and the "Scarlet Chinese" parent, and is expressed by the compound fraction 25//14/25, the double line separating the two parts that enter into this second union. Twenty-four plants were grown, and below some of the characteristics are given in tabular form:

Number of Plant.	SIZE.	COLOR.	FOLIAGE.	Spines.	Flowers.	Number of Fruits.
1	Medium	Purple	Dark, smooth	No.	Few.	24
2	"	"	" "	Yes.	"	27
3	"	Green	" "	"	Many.	12
4	Large	Purple	Large, smooth	"	Few.	7
5	Medium	Green	" white	"	Few, large.	15
6	"	Purple	Smooth	No.	Few.	3
7	Low	"	Purple	Yes.	Many.	24
8	*Medium*	"	*Oak-leaf*	No.	*Very many.*	9
9	Giant	Green	Long, crinkled	"	Few.	0
10	"	Purple	Large, smooth	Yes.	Many.	0
11	Medium	"	Long, smooth	"	Few.	12
12	Tall	"	" "	"	"	9
13	"	" (Green)	Medium, smooth	"	"	6
14	Medium	Green	" "	"	"	27
15	"	Purple	Long, crinkled	No.	"	24
16	Low	"	Smooth, crinkled	"	Many.	2
17	Dwarf	"	Medium, smooth	"	Few.	27
18	"	"	" "	Yes.	"	30
19	"	"	" "	"	"	25
20	Medium	Green	Long, smooth	"	"	10
21	Large	Purple	" "	"	"	2
22	"	"	" "	"	"	5
23	Medium	"	Medium, smooth	"	"	12
24	"	"	Long, smooth	No.	"	29

In size there were seven above medium, eleven medium and six low, or dwarf. The color of foliage shows that there were eighteen with purple stems and leaves and six that were green (one having some purple). Some omissions in the notes upon the foliage render it impossible to get the number of crinkled and smooth-leaved plants. Sixteen of the plants were with "spines" and eight without them; five were profuse with bloom in late autumn and nineteen bore but few flowers. In number of fruits the range was from none to thirty. The seven plants above

medium size averaged four fruits and the five below medium had one hundred and ten fruits. The two dwarfs bore fifty-seven fruits while the two "giants" were entirely barren. In this set of hybrids there was a direct correlation of fruitfulness and small size, besides it was the dwarfs that produced the largest and finest specimens of fruits.

If, by further experimentation, it is found that the dwarfs continue to be small-sized and fruitful, it will suggest that this characteristic type of plant may have its origin in breeding even when the parents are of the standard forms.

"Pride of Sunnyside" upon "Scarlet Chinese"—(20/25).

This set of fourteen plants was most remarkable in its vegetative power, producing enormous plants five and more feet high and proportionately broad, the leaves being uniformly quite large and slightly tinged with purple. As a whole, these two races of giant plants were nearly fruitless. The specimens that were obtained at the close of the season were usually smaller than those of the "Chinese" parent. The plants were extremely thorny, more so than any other hybrids that have thus far been grown, and exceeding to a large extent the spinose nature of the "Chinese" parent. One peculiarity, noted in this hybrid for the first time, is the pinkish color of the young, growing fruits, this color being held until near maturity, when it is displaced by a dull orange resembling slightly that of the "Chinese" parent. This color is evidently taken from the "American" eggplant, as it agrees perfectly in shade with those of our ordinary purple eggplants. In the lower half of Plate XI. is shown a collection of the fruits of this hybrid from eighteen plants at different ages of maturity in contrast with the "American" parent upon the left hand (1), while the "Chinese" (20) is shown upon the extreme right.

The small size of the hybrid fruits is shown by comparing the eighteen samples with the parents. Some attempts have been made to arrange the several specimens so as to place those most favoring the "American" type at the left hand, and as there is no marked difference to be noted, it is very evident that, so far as the fruits are concerned, they are quite uniformly alike in this set of blend plants. It is not until the next generation of plants is matured

that the variations may be expected. Some of the fruits in the engraving were photographed young and while they still held the purple color of the "American" parent. In other words, the small fruits at 9 and 14, in which the calyx still covers a considerable portion of the deeply-corrugated fruit, were decidedly purple, and suggested that these fruits may develop along lines of the purple parent and form fruits of considerable size. The extreme "spininess" of the stems of this hybrid may be noticed at 6 and 9, where the prickles resemble in shape and are in hardness like those of the brambles, making these plants disagreeable indeed to handle. Upon October 23d the final harvest was made, resulting in a total of sixty-seven fruits, the largest being two inches in the longest (equatorial) diameter, and containing but few seeds. The smaller fruits had all passed the purple stage, but showed strong bands of green radiating from the stem end, alternating with the orange that was replacing the purple and green. Many of the smaller fruits were, perhaps, not younger than the larger ones, but were uniformly seedless, to which condition the retarded growth may be due. The excessive spininess of this hybrid is manifest in the fruit stem and calyx, which were so covered with stiff prickles as to make the handling of the specimens a matter of discomfort.

Reciprocal Hybrids of American and Chinese Eggplants.

Seventeen blend plants were grown this season of the "Dwarf Purple" upon the "Scarlet Chinese"—represented in the records by the fraction 6/25. This set of plants was very uniform in size (two and a half feet high), and had purple foliage and stems, agreeing quite closely with the male parent. The bloom appeared the middle of June, and the plants continued to be full of flowers until cut down by the autumn frosts. There were only a few fruits produced, and these were small, much corrugated, and of a light orange color. The "Chinese" parent evidently was strongly prepotent in the fruit qualities, while the "American" seems to be more influential in the vegetative organs, but, upon the other hand, the "spines" of the "Chinese" were somewhat intensified.

A total of seventy-six (76) fruits of this hybrid was gathered upon October 23d, varying from two inches to three-fourths inch in longest diameter. The smaller fruits were all seedless, and the largest had only a few seeds.

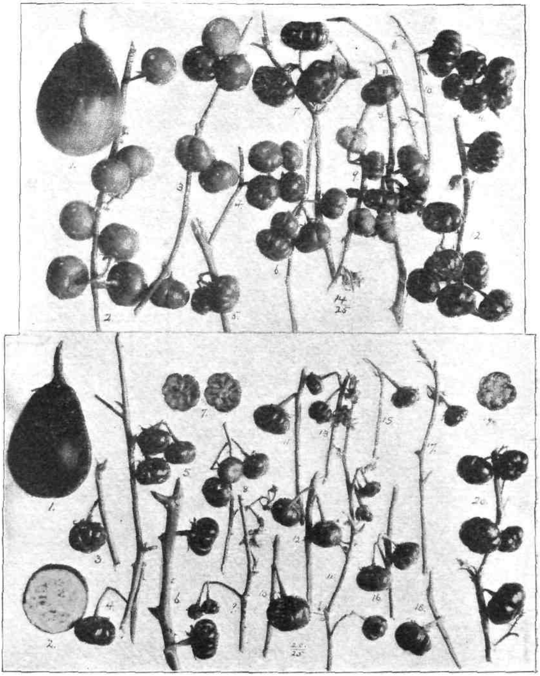


PLATE XI.

Eggplants. The upper half shows a series of stems with fruits of the "American-Chinese" hybrids (second generation). The types of the parents being shown at 1 and 12. In the lower half of the plate are shown samples of the blend of "Pride of Sunnyside" upon the "Scarlet Chinese," the parents being given at 1 and 20.

The reciprocal of the above hybrid was represented by eleven thrifty plants, resulting from the union of the "Scarlet Chinese" upon the "Dwarf Purple," the record fraction here being 25/6, that is, the reverse of the last. The plants were in full bloom upon August 9th, and the record shows that the plants were practically the same as those of 6/25, above described, excepting in the matter of size, they being uniformly over a third larger (four feet). The plants were almost covered with blossoms throughout the season, but were not prolific. A total of one hundred and fourteen fruits was gathered upon October 23d, varying from three-fourths inch to two inches in longest diameter; the latter only contained any seeds.

When the gathered crop of these two blocks of reciprocals was studied side by side a close resemblance was observed in size and form of the fruits, those of 25/6 being more uniform, but had the whole one hundred and ninety specimens been mixed together, it would have been impossible to separate them again into their respective piles. It is noted that the 6/25 produced only four and a half fruits per plant, while its reciprocal, 25/6, yielded an average of ten. In both hybrids there were plants entirely without fruits, and it was further observed that the smaller plants of each set were the most prolific.

Egyptian Eggplants.

Two packets of eggplant seed were received from the United States Department of Agriculture some weeks after the regular time for sowing, but were given a place in the Gardens.

No. 18543. "Black Fruit." This was represented by fourteen plants, which made a good growth for so late in the season, some of the fruits reaching a remarkable size before the frosts came upon October 12th. The plants and their fruit resembled quite closely the "Long Purple," but exceeding it in their vigor and compactness of growth. The fruits were all purple, excepting those of one plant, upon which they were nearly round and striped. (Seed will be saved, but it may be immature.)

No. 18544. "White Fruit." The fifteen plants of this lot were in nearly all respects similar to those of the above number and were inferior to it because the fruits (long and white) had a strong tendency to crack. Some of the plants were alongside of a giant hybrid eggplant and were overshadowed by it.

The above two lots of seeds were obtained by Mr. D. G. Fairchild from Mr. George P. Foaden, of Cairo, Egypt.

GENERAL NOTES UPON EGGPLANTS.

The work of breeding eggplants that has been carried forward for the past few years indicates that the number of well-established varieties is not large, and that several so-called kinds differ from some others little more than in name.

In size of plant, there are the tall kinds, like the "Black Snake" and "Pekin," and the low sorts, as the "Dwarf Purple," between which are grouped into two quite artificial sizes, namely, "medium tall" and the "medium short," the main portion of the popular sorts of to-day.

The color of foliage offers a point of distinction between some varieties, as the "Pekin" and the "New York Improved," but there are many kinds in which there is only a small amount of the purple in the plant, making it intermediate between the two extremes.

In color of fruit there is a character that aids in the separation of varieties, some being white and the larger number dark purple, while a few are pink and others striped.

The form of the fruit is fairly constant in some sorts, as the "Black Snake," with the long, often curved, "eggs," and the "Pekin," having a globular fruit. The oval is met with in several varieties, but the pear shape is more common and is quite typical of the truly dwarf sorts.

The point that has been particularly impressive is that of the added vigor of the blend plants in crosses between varieties of the garden species and the hybrids secured among the American and Chinese species. As has been elsewhere stated, it seems well worth the while for growers of this vegetable to make crosses between distinct types of eggplants for the special purpose of bringing in-

creased vigor and fruitfulness into the offspring. It has not yet been determined how long the renewed strength will last, and therefore it is well to secure fresh combinations every year.

The many reports that have been secured from those who grew eggplants for the first time lead to the opinion that the seedlings are less hardy than tomatoes and other garden plants started indoors, and their failure later on in the garden seems to emphasize the fact that eggplants need high feeding and abundance of moisture and sunshine. In other words, when under the best conditions they thrive almost like tropical vegetation, but in a lean soil, with lack of water, they sicken and barely live as fruitless plants. The plants of the Gardens could, doubtless, have been made more productive by adding food and drink, but one of the objects in the experiment was to study the crosses under possibly only average conditions.

Another method that obtained in the Gardens was entirely against the keeping quality of the fruits produced. The plants were unsprayed and the crop left to mature its seed, or at least so that the fruits might be studied. In this way the blights have been in evidence and some sorts suffered much more than others. All the dwarf sorts, with their small pear-shaped fruits, have shown remarkable resistant power to the decay germs (suggesting lines for future breeding), while the large-fruited sorts of the oval types have rotted worst of all. The long fruits that are held from the ground upon high plants are less apt to decay than the larger fruits borne upon the soil by medium-low plants. Again, the long, widely-scattered foliage of the "Pekin" type of plants lets in the sun to the fruits, and doubtless helps to keep them from decay.

It is not any great stretch of the imagination to conceive of a fruit that, while not differing greatly from the common sorts as to the interior, shall have a skin sufficiently firm and thick to shield the flesh from the microscopic enemies that work their way so quickly into the present type of fruits. A more secure natural cover would be welcomed by the shipper and dealer, and make it possible to have the large and attractive fruits of this vegetable reach the consumer in a more acceptable condition.

EXPERIMENTS WITH LIMA BEANS.

The "Station" and "Kelsey" bush lima beans were grown upon a small area of the Gardens, namely, four plot rows (a total of 128 feet) were planted with the latter, and of the former, selected "flat" seeds were planted in four rows and "plump" seeds in an equal area. Thus there were twelve rows of the "Burp-hends" grown in three blocks of four rows each, side by side.

The "Kelsey" was noticeable for the uniformity of the plants. In the "Station" there was some tendency to twine, especially in the four rows planted with the "plump" seeds. During the wet weather of August the flower-stalks and young pods mildewed somewhat, and were freely sprayed with Bordeaux. Later on the mildew disappeared and the crop was harvested with results given later.

The "Kelsey" is an earlier variety than the "Station," with the plants smaller and approaching the "Henderson" parent—the Sieva type. Its foliage is darker than that of the "Station" and less susceptible to the mildew. When it was harvested upon September 6th the "Station" was still in bloom. There were 118 plants, of which 13 were discarded as being later and less prolific than the others, and 49 of the remaining 105 were selected as superior—from which the crop for next year is to be grown—and 56 as seconds.

Eleven days later, there having been no frosts, the "Station" blocks were harvested, with the following results: Of the 101 plants from the "flat" seeds, 31 were rejected and the remaining 80 were graded as follows: Extras, 10; fine, 12, and seconds, 48. The "plump" lot had 114 plants, of which 64 were rejected, leaving extras, 10; fine, 6, and seconds, 34.

The weights of ripe seeds for each of the three blocks are as follows: "Kelsey," 7½ pounds; "Station" (plump), 5¼; "Station" (flat), 7¼. It is seen that the "Station," with plump seeds and from plants that inclined to be "viney," gave a much smaller yield than the "flat" strain, which in turn was exceeded, although but little, by the "Kelsey."

The upper half of Plate XII. shows samples of the two strains of the "Station" beans. The watch glass upon the left contains the "plump" seeds, and the same kind is shown, placed edgewise,

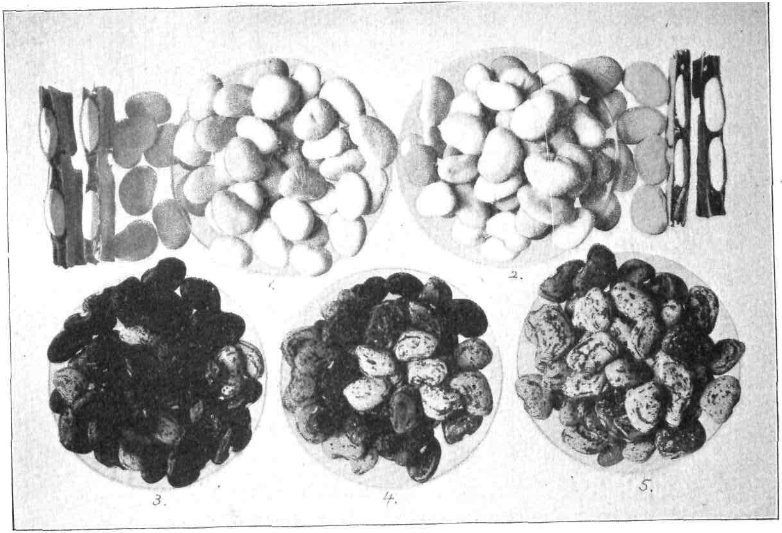


PLATE XII.

... the "Jackson Wonder" with samples of

still further to the left. In like manner the "flat" strain is shown to the right. The difference is not great, but it may be possible, through several years of isolation, to fix both forms and compare the value of each.

Reports Upon "Station" Bush Lima.

Packets were sent to each of the one hundred and twelve applicants, and below abstracts are given from the reports kindly submitted: "'Station' bush limas all turned out well; they couldn't have been expected to turn out better." "Limas of good quality for eating; good beans; strong, healthy, fine vines; no blight of any kind." "Think these beans are the best we have ever seen, and most productive; plants large, with medium green leaves." "Strong growers, and made plenty of seed pods." "Vines grew strong and were fairly well set with pods containing from two to four beans, mostly small, flat and pure white, and of good quality." "Fruit of good flavor." "The bush limas have done well, and are a valuable addition to the vegetable garden, being early and profuse bearers." "Was noted as a strong, vigorous grower; produced an abundance of small-podded beans, but pods were well filled; it would prove valuable as a home garden variety; its cooking qualities were good, sweet and tender." "The 'Station' bush limas have been very satisfactory; they have borne unusually well, and the plants are covered with blossoms, so the beans are of good size and run three or four to a pod; the flavor is exceptionally good." "Good size, good taste and good production." "The limas you sent me are very productive and vigorous." "At this date (September 18th) the 'Station' bush limas are still bearing; they are almost equal in size to the pole beans, and are very productive." "Vigorous and very productive; shape like an ordinary lima bean, but smaller; fruit very uniform; about three inches in length." "The limas made a vigorous growth of vine and foliage, and were very profuse bearers; quality good." "The plants grew and yielded well." "Did all right; quite prolific." "Think with careful cultivation would prove a good species." "The 'Station' bush lima is a good, rank grower; dark green foliage, with a fairly good set of fruit; the pods uniform in size." "A very good producer." "The 'Station' bush limas are a good-sized bush; small beans, three

in most pods; they have flat pod and white beans; quality good and middling early; as good, and probably better, than any bush lima that I have ever had any experience with." "They are a very fine lima." "Were vigorous and very productive, and of good flavor." "Bean stood about fifteen inches high; very vigorous, producing a small pod, heavily filled with plump beans and very prolific." "Did very well; have noticed that growth is very vigorous, with very few runners, pods containing three or four beans of good size; think it quite valuable." "Very productive, there being from twenty to thirty pods on the vine at a time, three to three and a half inches long, having three and four beans to the pod; in shape and uniformity they were perfect—they were all alike." "Size was small, but vigorous grower and very productive." "The lima beans have grown finely; are still vigorous and bearing as well as any I have ever grown; the fruit is very uniform." "Limas are very productive, vigorous plants, bearing white fruit of excellent quality." "Very good flavor." "Very vigorous and exceedingly productive." "Plant is very vigorous." "Vigorous and healthy; leaves very dark green, very productive; beans small, with three in pod; the quality of the bean much better than 'Burpee's'." "Vigorous plant, about thirty per cent. inclined to climb; exceedingly productive; beans uniform, good size, even shape, good quality." "Very productive, having three small, yet perfect, beans in each pod, which shelled very easily." "Fine quality, pods well filled with medium-sized beans; very productive, excellent for home garden."

Selection Experiment with the "Jackson Wonder" Lima.

The "Jackson Wonder" lima is a bush bean, having the plants of medium size with the leaves having dark, small leaflets and the flowers and fruit borne well up from the ground and frequently among or above the foliage. It is, in short, of the "Sieva" type, the most common representative of which in general culture to-day is the "Henderson." It is prolific, and, were it not for the color of the seeds (which are variably marked with dark red or purplish blotches), this might be one of the most desirable of lima beans.

For some years an attempt has been made to reduce the amount of red color in the seeds by selection. In 1904, a block of plants

was planted with seeds selected for having the least amount of color, while another lot, showing the largest percentage of red, was planted in a plot a long distance from the former. From the crop secured from each of these plots a second selection, in manner as above stated, was made, and as a result it was stated in the last annual report that "the light seed from the light seeds are nearly as dark as those from the second generation of selected dark seeds." The present year a block of plants has been grown from the lightest seeds that are descendants of the seeds selected for their large percentage of light color, and another from similarly selected dark seeds. A sample of the product for the latter is shown at 3, in Plate XII. A similar sample of the light seeds is shown at 5, while the original unselected "Jackson Wonder" is placed between the selected seeds at 4.

It is seen that selection has removed much of the white in the case of the series of dark seeds, while the opposite is not so evident, namely, the seeds after three years of selection for whiteness are nearly as much colored as the regular stock of the variety.

Crosses of the "Jackson Wonder" Lima.

The "Jackson Wonder" lima has been grown in the Gardens for some years in parallel breeding rows with other varieties in the hope that it would cross in the ordinary course of nature—the working force not being sufficient to carry out the plan by artificial methods. Two rows, six inches apart, one of "Jackson Wonder" and one of the sort to be bred upon, were planted, isolated from all other lima beans, and seed from the row with white seeds was planted in considerable quantity the next season. In this way plants with "marked" seeds were obtained last year (1905) with several kinds of lima beans. From the crop coming from these striped or mottled beans—and frequently they were of a solid purple color—certain of the crosses shown in Plate XIII. have been selected.

Sample seeds of the cross of "Jackson Wonder" upon "Burpee" are shown in the upper rows; ten seeds of the male parent are at the left (1) and the same number of the mother at the right (5), the piles between representing the crosses—three in this instance—each pile in all cases being the full product of a single plant. The

seeds at 2 are somewhat larger than the "Jackson" and the color is nearer a dull red than a dark purple as in the male parent, and the seeds of the cross are more nearly alike in their marking than in the "Jackson," in which there is a decided tendency to produce dark seeds, some of which are shown at 1. The seeds at 3 are uniformly of a dark red and not at all striped or mottled and are slightly larger than the "Jackson." At 4 the seeds are not far from those of 3 in color in the picture, but show some differences when a close comparison is made of the two. The plant was less prolific and seems to be somewhat nearer the "Burpee," ten seeds of which make the end pile at 5. The one white-seeded crossed plant did not have seeds ready when the picture was made.

In the next row are shown four crosses of the "Jackson" upon the "Henderson." As the former is the male parent in all the crosses shown in the plate, seeds of it are omitted in all except the first row. Here the seeds are generally not as large as when the "Burpee" blood is present, but it is evident when this row is further compared with the one above it that the "Burpee" has not fulfilled the expectations as to the hoped for increase, the size of the crosses. In other words, the "Jackson," as regards size, has a stronger influence upon the progeny than the "Burpee," and again illustrates the familiar result in breeding that it is easier to hold down than to lift up. Upon the other hand, as regards prolificness, the "Burpee" seems to impress its lack of fruitfulness upon the cross, which is only another instance of the greater downward pull. The two plants, seeds of which are shown at 6 and 7, respectively, were quite alike; in fact, the plants of the whole plot were uniform, as might be expected, for both parents are nearly the same in characteristics outside of the color of the seed. At 8, the seeds are of a handsome dark purple, uniform in all respects and quite different in superior plumpness from the flat and somewhat larger seeds at 4. In this set of crosses there were several white-seeded plants, and the pile at 9 indicates that these "albinos" are decidedly prolific. They are placed in comparison with the "Henderson," the selected seeds of which are shown at 10.

The third row deals with the crosses of the "Jackson" and "Wood's Prolific." The latter has a plant and seed somewhat between the "Burpee" and "Henderson." The seeds shown at 15 indicate this fact, so far as the beans are concerned. The crosses

were perhaps a trifle more productive than those with the "Henderson" with the advantage (to many growers) of producing large seeds. The seeds shown at 11 are marked nearly in the same manner as those of the "Jackson." At 12, the seeds are purple with the exception of an indistinct blotching of a lighter red upon the dark background. In the next lot the marking is conspicuous, but, being of two shades of red, it is not shown in the engraving. It is as if the markings in 11 were nearly black and upon a bright red background. Here, again, as in all the crosses except with the "Burpee," there is a fair percentage of white-seeded plants. It is in these "albinos" that the hope lies of getting improved crosses with the "Jackson," the seed-color being objected to by the housewife.

At 16 is shown the seeds of a plant of the "Jackson" upon the "Willow-leaf," the thought here being, among other things, to secure a variety with all the fruitfulness of the "Jackson" combined with the form of foliage in the "Willow-leaf," the latter being more desirable because of its openness, and therefore less subject to the mildew now becoming a dread to the grower of lima beans. The most prolific plant, seed of which is shown in the plate, is represented at 17. The output, while satisfactory, is undesirable from the standpoint of color. There is probably no difference in quality between these and white beans, and the blind would not know that they were dark, but all are not blind, and the white strains will be preferred to the dark ones. At 18, the seeds of a dull-brick red with slight indications of a mottling, characteristic of the "Jackson," are shown. In color, these lie between the dark of 17 and the light of 19, which latter are from a fine productive plant. These white seeds are not quite equal in size to those of the selected ten of the "Willow-leaf" lying nearby at 20.

The lowest row represents seeds of selected plants, among the first generation from the cross of the "Jackson" upon the "Station." The latter is a variety resulting from the union of "Burpee" upon "Henderson," and is a blend of the two in several characteristics. The pile at 21, representing the "Jackson" type, is a set of fine seeds; those at 22 are of the dark purple previously mentioned, while pile 23 is a set of uniformly dull red beans, standing between the dark ones upon the left and the white ones

at 24. There is hope that the last-named seeds may, by breeding true to their color, produce a prolific variety of lima of the medium type so far as size and quality of the beans are concerned.

Had there been a white representative in the first series of crosses (upper row in the plate) it might have been possible to have arranged the piles so that, with uniformity, the left-hand piles would represent the "Jackson" seeds, so far as color values are concerned, and have each row end in a white pile, representing the color of the female parent, between which extremes there might have been placed the two intermediates, as has been done in the lower three rows in the present plate.

Further Notes upon the Above Crosses.

"Jackson-Burpee" (91/80).—The plants, though few in number, presented much variation in respect to foliage and fruit, some closely resembling the "Jackson," a few the "Burpee," while others were intermediate. One plant bore an abundance of pods quite as large as the "Burpee," with large flat seeds of a dark red color.

"Jackson-Henderson" (91/89).—This cross was well represented by thirty-seven plants, which were quite uniformly of the "Sieva" type in foliage and pod, and many gave promise of a bearing quality equal to that of the "Jackson."

"Jackson-Wood's Prolific" (91/98).—The forty-one plants, grown by themselves, varied in developing a strong tendency to "run." Thirty-five truly bush plants varied in habit of growth and color of foliage from upright to spreading, with dark green to light green leaves, and one differed remarkably from the rest in its larger, light green leaves, larger pods and spreading habit.

"Jackson-Willow-leaf" (91/97).—Plants were grown from seed selected in both the "Jackson" and "Willow-leaf" rows, and the crosses were divided about evenly in regard to foliage characters. An examination of the seed from twenty different plants, chosen at random—ten of which were "Willow-leaf" and ten "Jackson," upon the maternal side—showed the average size and form to be the same in both cases. One plant of the "Jackson" type was noted as having seed larger than that of either parent.

"Jackson-Station."—This cross, represented by the largest number of individuals (182), showed a plant variation from the

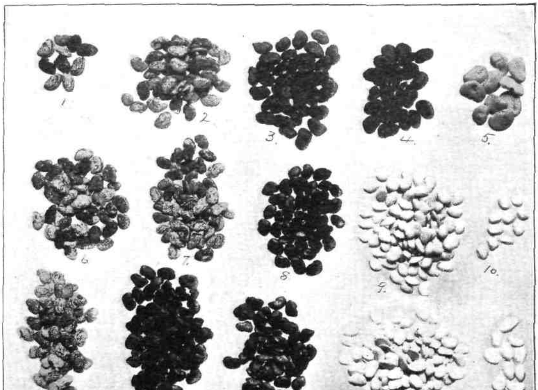


PLATE XIII.

"Sieva" to the large-leaved type, while one plant developed a strong tendency to "run." At harvest time the bearing quality was found to be excellent, with a variation in pod and seed from that of the "Kelsey" to the "Station."

The following is a grouping of the seed colors for each of the above-named crosses:

	"Jackson" Type.	Dark Red.	Light Red.	Brick Red Mottled.	Light Red Mottled.	White.	Total.
"Jackson-Burpee"	10	4	....	....	....	1	15
"Jackson-Henderson"	21	9	....	....	1	6	37
"Jackson-Wood's"	35	15	....	2	2	22	76
"Jackson-Willow-leaf"	22	10	1	4	3	15	55
"Jackson-Station"	29	13	10	....	8	22	82
Total	117	51	11	6	14	66	265

It is seen that the white-seeded plants make up almost exactly one-fourth of the total and, according to the Mendelian law, the white might well be expected to be dominated by the red color. Should all the mottled ones be grouped together, the total 137 would correspond very closely to the theoretical number (132.5) for the "hybrids," thus leaving the solid red 62, which is quite close to the quarter (66) of white ones.

Notes upon Pole Lima Beans.

Only three pole kinds of lima beans were grown the past season, namely, (1) "Station" (selected pole), (2) "Willow-leaf" and (3) "Speckled Lima."

In 1905 seed was selected from certain of the "Station" plants which showed a strong running tendency. All the plants grown from this lot of seed were true pole beans, thrifty and prolific, with the "Station" type of pod and seed.

Seed was saved from a "Sport" of 1905, which appeared in a standard row of the "Sieva" type. Five hills were planted, most of the plants being true to the parent type, and all others were discarded.

Of the thirteen plants eleven were pole beans and two were dwarfs, five of the former having more vigor than the others and bearing broader foliage than the true "Willow-leaf" form, and larger pods and seeds than the ordinary "Sieva" type.

A few seeds of the "Speckled Lima," received in 1905 late for planting, were grown, and matured a small crop. From this two plants resulted the present season, both resembling the "Burpee" in pod, while the seeds are marked with red.

EXPERIMENTS WITH BUSH BEANS.

The seventy-six crosses, made during 1904 and 1905, were planted April 25th–29th in the new land. When these were nearing maturity a second crop was planted (July 24th–28th) between the old rows, and from this there were ripe seeds before October 18th, the date of the first killing frost. Many of the crosses have advanced to the fourth generation and a few beyond it. Fifty additional crosses were made the past season, some of which have been carried through the blend.

With the ideal snap bean in mind—a medium-sized, round, white-seeded, stringless, prolific, early wax or green pod—three general divisions of the crosses may be made, namely, desirable, uncertain (or doubtful) and the rejected.

Some Promising Crosses of Bush Beans.

"Earliest Green Pod-Bismarck" (14/102).—This cross is interesting, as it combines the green and wax-pod characters. Three hundred and thirty-one plants were grown of the second generation and gave four distinct colors or markings, of which 80 were black, 28 brown, 198 mottled and 25 tricolor. The mottled include the parent type (14), the brown closely resemble the "Six Weeks" type of seed and the "tricolor" is a curious mottle made up of three colors. Seeds of this cross are shown in the upper row of Plate XIV.

"Everbearing-Cylinder" (17/110).—The "Everbearing" is represented by a long, flat, green pod with flat, white seeds. "Cylinder Wax," a round, stringless, black wax pod, is undesirable only in the color of its seed, a defect which may be easily overcome in the cross by selection. The aim is to combine several desirable qualities, and secure a stringless, round-podded, white-seeded wax bean.

"Longfellow-Marrowfat" (26/29).—This cross combines the early, long, round, stringless, green pod of the "Longfellow" with the white seed of the "Marrowfat." By selection, it seems possible to secure a long, round, white-seeded, green pod, qualities which no commercial variety in the Gardens has been found to possess in full. Seeds of this cross are shown in the second row of Plate XIV.

"Longfellow-Brittle" (26/101).—This cross, together with its reciprocal, 101/26, promises either a round, stringless, green pod with the "Longfellow" type of seed, or a round wax pod with the "Brittle" kind of seed, and either may make a desirable new variety. Plants of this cross are prolific and early and a wax with the pods borne above the foliage like the "Longfellow" would be superior to the mother.

"Brittle-Yosemite" (101/146).—This combines the excellent qualities of the "Burpee Wax" with the remarkably large, fleshy pod of the "Yosemite." By rejecting the black-seeded plants, there is promise of a mammoth "Burpee" type superior to the "Yosemite" in prolificness.

"Bismarck-Detroit" (102/113).—This cross, which has been carried to the sixth generation, was shown in the annual report for last year, Plate VIII., which represented seed from sixteen different plants, all grown from a mottled seed of a plant of the second generation. Of these, two were black-seeded, five with the dark "eye" of the "Detroit" and nine were mottled. The "dark eye" seeds have bred true up to the fifth generation. One of these has a long, flat, straight wax pod with a seed like "Bismarck" in form and giving a superior golden wax bean.

"Davis-Black" (11/107).—This is a combination of the long-podded, white-seeded "Davis Wax," and a medium length, round-podded "Black Wax," and is promising.

"Davis-Refugee" (111/133).—This cross unites the fine qualities of the "Keeney Refugee" with the longer, white-seeded pod of the "Davis." The object sought here is a white-seeded "Refugee."

"Scimitar-Davis" (129/111).—Both parents are prolific bearers of large pods, the "Scimitar" being a round, curved, black-seeded wax. Out of this combination it is hoped to obtain a white-seeded "Scimitar Wax."

"Golden Eye-Boston Snap" (130/3).—Although neither parent is round-podded nor stringless, both are early and prolific. "Golden Eye" is a fine, flat-podded wax and "Boston" has white seeds. A combination of the two has resulted in a medium-sized wax pod and the seeds are, by selection, uniformly white.

"Jones' Stringless-Golden Eye" (131/130)—Both the parents of this cross are early, prolific varieties with pods of medium size. This union of a yellow-"eyed" variety with one with white seeds has resulted in a curious and unexpected type of seed, namely, one with a dark mottle, excepting at one end, which is white, and which by selection seems to be quite constant. The third row in Plate XIV. shows several groups of seeds of this cross.

"Crystal-Brittle" (145/101).—The "Crystal Wax" is a medium-sized, late plant with peculiar light, silver-green, round, curved pods with small white seeds. It is a variety of high quality, but the pods are too small. The "Brittle Wax" is one of the best varieties of its kind, being early, prolific and with round, stringless pod of good size but lacking the pure white seed. By a combination of the above qualities, and selecting white-seeded plants, a new variety superior to either parent is looked for. Forty-four plants of the first generation were grown, the color record being as follows: White, 10; black, 21; mottled, 10; brown, 3. Certain plants bore fine specimens of "Crystal Wax" pods larger than the parent, other plants produced a fine white wax, while many were green pods. Present indications are that this is one of the most promising of all the crosses. The blend plant of this cross, although both parents bear white flowers, produced purple blooms, and the seeds were but slightly mottled, being nearly a solid black when dry. Seeds of this cross are shown in the lower row of Plate XIV.

"Crystal-Davis" (145/112).—Both parents are choice white-seeded wax varieties. The blend produced green pods with white seeds, which gave in the next generation a fine, round, white wax pod, medium in size. No colored flowers or seeds have appeared in any generation.

Further Notes Upon Seeds of the Above-Named Bean Crosses.

From among the above list of crosses of the bush beans four groups are selected for a combination group in Plate XIV. The first pile of each row represents the male parent of the crosses in its respective row, while the last pile is correspondingly the female. Thus, in the first row, the beans at 1 are of the "Earliest Green Pod" (No. 14 of the recorded list), while the variety crossed upon is represented at 7, namely, the "Bismarck Wax" (102). All of the crosses shown between the piles 1 and 7 are represented by the fraction 14/102, which, as before explained, indicates that the green-podded sort was used as the male, while the wax variety bore the seeds obtained by the artificial pollination.

The "Earliest Green Pod" is a variety with a large, medium early plant, bearing pink flowers, followed by long, flat pods containing medium-sized light brown seeds with curved bands and blotches of pink. The "Bismarck" is an early, medium-sized variety with purple flowers, long, flat wax pods that mature black, plump seeds, below medium size. The ten seeds of each sort at the ends of the upper row in the plate give relative sizes and something of the color characteristics of the two varieties.

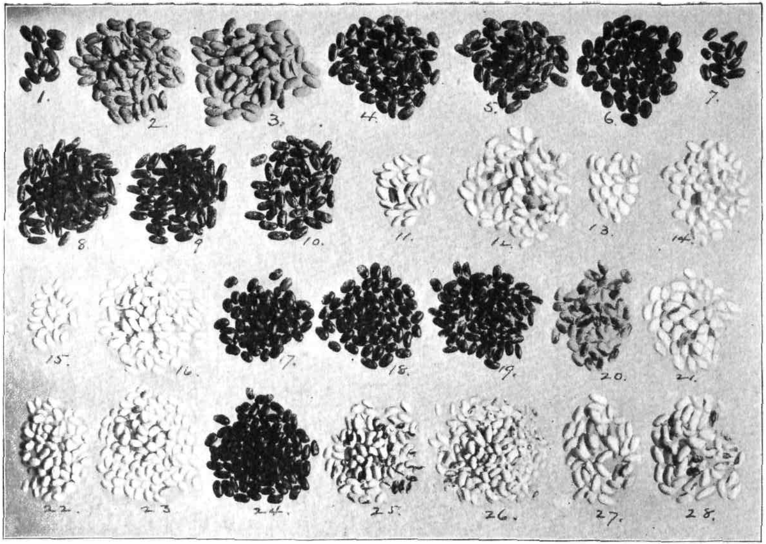
The seeds of the crosses are arranged somewhat according to the apparent resemblance to the parents, and therefore at 2 the beans approach the form and markings of the male parent (1), but they are much lighter and longer and more attractive to the eye. At 3 the seeds are without markings excepting a distinct brown eye, while the body of the seed is colored an olive tan not altogether pleasing to the eye and not met with in any of the commercial sorts in the collection.

The seeds of 4 are coarsely mottled with nearly a seal brown upon a lighter background, giving a bean that photographs nearly black, but is a mixture of two closely-related browns, and producing a strange-looking seed that in itself is unattractive. Quite in contrast with the last is the lot at 5, where the amount and disposition of the markings are practically the same as in 4, but the contrasts are strong between the two colors, namely, a dark purple upon light gray, thus producing an attractive bean. The seeds at 6 are practically black, as much so as the "Bismarck," near which they are placed in the plate. The two, however, are quickly dis-

tinguished by the shape, it being very flat in the cross, and therefore the seed appears much the larger of the two in the picture.

The second row deals with the "Longfellow" (26) and "White Marrowfat" (29), both green-podded sorts and differing from each other markedly in the color of the flowers, shape of pods and color of seeds, the "Longfellow" having pink blooms, round pods, and long, mottled (dull red and gray) seeds, while the "Marrowfat" is with white flowers, flat pods, and large, short, plump white seeds. The sample plant, selected as nearest to the male parent, has its seeds, in part, shown at 9. They differ somewhat in the markings, or, more accurately, in the greater difference in the colors between the darker portions and the background, thus giving a more attractive lot of seed. They are also somewhat shorter and broader than the "Longfellow." The next lot (10) differs chiefly from the last in the much lighter color of the markings. Both are much blotched like the male parent, and differ from it in being less slender. At 11 the seeds are white, like the "Marrowfat," but have the shape of the "Longfellow," and taking the two named qualities into consideration, this lot merits a midway place in the row. The next lot (12) is a step nearer the "Marrowfat," and the ones at 13 are not easily distinguished from it. The gradations in shape are much more easily worked out than those of color, for the plate shows that three lots are dark and four light, with but little intergrading—a little less, however, than in reality.

The third row has points of special interest because the two parents pass for white beans, the male parent, "Jones' Stringless" (131), being entirely so, and the mother of the crosses is white, with a dull yellow eye, giving the name "Golden Eye" (130) to this variety. The plants of both sorts are medium-sized, white-flowered, with the "Jones" having a medium, round pod and the "Golden Eye" a short, flat one, the latter having the larger seed. At 16 is shown a pile of white seeds that agree quite closely with the parent shown upon its left (15). The seeds shown at 17 are a plain tan, and therefore somewhat darker than the color of the "eye" in the female parent. The seeds at 18 are unlike any other in the series in being mottled on nearly the whole surface with two shades of brown, the exception being a white tip at the root end of the bean. The same white extremity is still more conspicuous in the next lot (19) because the uncolored area is larger and the main



1.
2.
3.
4.
5.
6.
7.
8.
9
10.
11.
12.
13.
14.
15.
16.
17.
18.
19.
20.
21.
22.
23
24.
25.
26.
27.
28.

portion of the seed is a plain black. This peculiar disposition of color is to be made out by a close inspection of the engraving, but, in reality, it is very evident, giving the seeds a striking characteristic. At 20 the seeds are quite suggestive of the female parent (21) because the light tan color, confined to the "eye" in the latter, is here spread over nearly one-half of the seed, as is quite plainly shown in the engraving.

In the fourth row the two parents are "Crystal Wax" (145) and "Brittle Wax" (101), the former being the male, and is a variety with a small plant and white flowers, producing short, round, curved pods, thick in flesh and bearing very small, oval, white seeds late in the season. The "Brittle Wax" is a medium-sized plant, fairly early in bearing, with white flowers, long, round pods, and medium large, long, often curved, seeds with a dark "eye."

Points of contrast are many between these two varieties, not the least being the color of the pods which is a pea-green in the "Crystal," due to the chlerophyll being located largely in a layer at a distance from the surface of the pod, while the "Brittle" is of the true wax type.

At 23 is shown the seeds of the third generation of a white-seeded strain of the cross. It is much more productive and somewhat earlier than the "Crystal," and the seeds, a decided oval, are somewhat larger than the latter. The seeds at 24 appear nearly black but are a dark, mottled brown and quite near in this respect to the blend obtained from the original cross. At 25 is shown a set of seeds in its second generation which are remarkably long and curved, medium between the two parents in size and with a dark "eye" that considerably exceeds the "Brittle." The seeds at 26 are still smaller and decidedly curved, with a dark color at the "eye" that is usually only a portion of a circle. This shape of seed seems to be correlated with a round, plump pod much sought for. The seeds at 27 are pure white and of a shape that agrees quite closely with the "Brittle" (28) near which they are placed.

A study of the combinations of characteristics that do not pertain to the seeds shows some points of interest in the breeding of these plants.

Less Desirable Crosses of Bush Beans.

"Canadian Wonder-Golden Eye Wax" (8/130).—The male parent is a large, stocky, thrifty plant with long, flat, green pods containing large, flat seeds. The "Golden Eye" is an early, hardy, prolific wax with flat pods of a medium size. A combination of the two has resulted in an early, prolific plant bearing a large, flat wax pod having seeds with a pink "eye," and no wax variety yet grown at the Gardens has this type of seed.

"Dwarf Chocolate-Burpee's Brittle Wax" (11/101).—The union of the "Dwarf Chocolate," with its slender green pods, with the "Brittle," having round, curved wax pods, has resulted in plants bearing two distinct types of fruit, namely, a slender, curved green pod with "Burpee Brittle" type of seed, and second, a long, round, curved, slender wax pod with either parent type of seed as desired.

"Dwarf Chocolate-Flageolet" (11/114).—The "Flageolet Wax" is a large, broad, flat pod which, by the infusion of "Dwarf Chocolate" blood, has become much more slender while retaining its golden color and prolificness. A plant bearing slender wax pods with chocolate-colored seeds may be obtained by this cross.

"Lightning-Eclair" (25/13).—The "Lightning" has mottled flowers and is extremely early. As a snap bean it is undesirable, but, in the combination above, the slender pod of the "Eclair" is retained with the earliness of the "Lightning." Selection is being made to obtain a plant with striped flowers bearing "Eclair" pods with "Lightning" seeds which are of a peculiar mottled gray color.

"Lightning-Marrowfat" (25/28).—This combination has resulted in a very early, white-seeded cross, which, if not desirable as a snap bean, promises to be a good "shell' variety especially where the season is short. Plants grown from the first crop, harvested the last of July, matured seed fifty-four days from the time of planting.

"Lightning-Prolific Tree" (25/34).—This cross is similar to the one preceding but has a smaller white seed. It also gives promise of being an early "shell" bean.

"Lightning-Davis' Wax" (25/111).—Selection from this cross has resulted in two types, (1) an early plant bearing long green pods with large, white seeds, and (2) a kind having a long, flat

wax pod with the same seed color. Both are inferior to "Davis" as a snap bean, but they may become good new "shell" varieties.

"Longfellow-Cylinder Wax" (26/110).—This is a combination of two good varieties and has produced as one type the "Cylinder" pod with the "Longfellow" seed.

"Low's Champion-Golden Wax" (27/122).—A union of these two varieties has developed a "Golden Wax" pod with the round, red seed of "Low's Champion" pointing to a red-seeded "Golden Wax."

"White Marrowfat-Canadian Wonder" (29/8).—Both varieties represent late plants with large pods and seeds, and, as the "Marrowfat" has a white seed, this means that by selection of the white-seeded plants a new "shell" variety resembling the "White Kidney" (182) may be obtained.

"Henderson's Black Valentine-Detroit Wax" (45/113).—By uniting the good qualities of the "Henderson," a long, round, stringless pod, with the golden color and earliness of the "Detroit," plants bearing a superior golden wax have been secured. Plants have also resulted, promising the "Black Valentine" pod with the "Detroit" dark "eye" seed.

"Stringless Valentine-White Marrowfat" (46/29).—The outcome of this cross is an upright, sturdy plant bearing an abundance of short, straight, round pods. The selection of white-seeded plants means a combination of string and shell bean with a plant superior to the "Marrowfat" in two respects, namely, earliness and true dwarf habit.

"Green Winter-White Marrowfat" (51/28).—Both these varieties have white seeds and their combination results in a plant earlier and more bushy than the "Marrowfat" with short, plump pods. This cross promises another "shell" variety.

"Burpee's Brittle Wax-Wonder of France" (101/52).—Here the white seed of the "Wonder" is combined with the good traits of the "Burpee" producing another white-seeded wax bean.

"Detroit Wax-Black Wax" (113/107).—The "Black Wax" has a round pod and this union resulted in a round-podded "Golden Wax," and, by selection, the "Detroit Wax" type of seed is assured.

"Flageolet-Detroit" (114/113).—From this combination plants have resulted with the large, flat pod of the "Flageolet," containing large, flat seeds with a red "eye" similar to the "Detroit."

"Flageolet-Golden Eye Wax" (114/130).—Results from this cross are similar to the one above, producing a large, yellow-"eyed" instead of a red seed. If the smaller pod of the "Golden Eye" is preferred, by the selection of red-seeded plants, a new "Wax" with the red seed can be obtained.

"Flageolet-Saddleback Wax" (114/141).—The "Saddleback" is a good, round pod, and, in combining it with the "Flageolet," a red-seeded "Saddleback" may be obtained.

"Golden Eye-Dwarf Chocolate" (130/11).—The selected plants of this cross bear long, slender wax pods, containing a long, yellow-"eyed" seed; this may be an improvement upon the "Golden Wax" in size and shape of pod.

"Keeney's Refugee-Burpee's Brittle Wax" (133/101).—Both varieties possess the good traits of prolificness with a round, curved, stringless pod, but the "Keeney," with its characteristic narrow-leaved foliage, is later than the "Burpee" and has a mottled seed. One of the objects sought in this combination is a plant with "Keeney" foliage and a "Burpee" seed.

"New Profusion-Wardwell's Kidney" (137/144).—"New Profusion" possesses the "Keeney's Refugee" characters of plant, pod and seed, while "Wardwell" represents a plant bearing long, flat pods with a dark-"eyed" seed. The object of this cross is a variety with "Refugee" type of plant and pod and seed marked like the "Wardwell."

"Crystal Wax-Dwarf Chocolate" (145/11).—Uniting the peculiar pod color and white seed of the male parent with the long, slender pod of the "Dwarf Chocolate," an improved "Crystal Wax" is hoped for.

"Crystal Wax-Bismarck Wax" (145/102).—This is another combination with the "Crystal Wax," and, by selection of plants bearing longer pods with white seeds, an improvement may be secured.

"Crystal Wax-Flageolet" (145/114).—This cross does not produce a round pod, as hoped, but a prolific sort of the "Crystal Wax" type, with a large pod and small white seed, is anticipated.

"Crystal Wax-Yosemite" (145/146).—By selection of plants resulting from this union a mammoth-podded "Crystal Wax" is sought, and, by selection, plants with wax pods, a white-seeded "Yosemite" mammoth is expected.

"Livingston's Pencil Pod-Eclair" (148/13).—The "Pencil Pod" is of the "Refugee" type of foliage, with longer pods, which, combined with the long, green, flat pod of the "Eclair," has resulted, by selection, in a long, green, curved, round pod, with either brown or mottled seeds. This promises a fine, new green pod variety.

Rejected Crosses of Bush Beans.

The following crosses are rejected because, from the economic point of view, they seem to promise nothing superior to the parents involved. In other respects they offer quite as much of interest as do those of the "Promising" groups:

"Bountiful Bush-Lightning" (2/25). Earliness was the main thought in effecting this cross, twenty-two first and ninety-seven second generation plants being grown. Many of the plants were the first in the field to bloom and the dark-green foliage of the "Lightning" was evident, as also its long, green, flat pods. The dominant seed colors were brown and dark mottled.

"Byer's Bush-Longfellow" (6/26). By uniting these two excellent green-podded varieties it was hoped to secure something better than either. Both parents are early and prolific, with round pods, the "Longfellow" being much the longer.

"China Red Eye-Best of All" (9/1). With this combination, the object was to secure a new variety with a red-"eyed" seed. Thirty-four plants of the first and twenty-four of the second generation were grown, the "red eye" becoming a fixed character in the offspring of two plants, but no advance was made in earliness, type of pod or bearing quality.

"Crystal Wax-Henderson's Black Valentine" (10/45). The cross plants, one hundred and nine in number, were late, wide-spreading and bore small pods.

"Dwarf Chocolate-Mammoth Stringless" (11/40). Considering the dark-green, narrow-leaved foliage and long, slender pod of the "Chocolate," and the round, stringless pod of "Mammoth," their union pointed to a prolific offspring, with "Chocolate" type of foliage and a long, slender, round, stringless pod. Twenty-three plants, all of the first generation, were grown, the plant characters of "Mammoth" dominating, but the desired long, slender, round pod failed to appear.

"Dwarf Chocolate-Six Weeks" (11/55). Of the seventeen first-generation plants grown, none was earlier, more prolific or longer-podded than "Six Weeks."

"Lightning-Burlingame Medium" (25/5). This cross was represented in the field by twenty-five first and fourteen second generation plants. The prepotency of "Lightning" was shown in the offspring, resulting in early plants with dark-green foliage, but they were not prolific and bore flat, stringy pods.

"Lightning-Longfellow" (25/26). As in the cross above (also the two following), the male parent dominates. Of the seventy-two plants grown in the field, forty-one were of the first and thirty-one of the second generation. A "Longfellow" plant and pod with seed of "Lightning" was sought, but no plants developed full, round pods, so desirable in the "Longfellow."

"Lightning-Wonder of France" (25/52). This combination offered an earlier white-seeded, green pod. Forty-eight plants were grown during the past season, nineteen of the first generation and twenty-nine of the second. While the plants were early, the pod was inferior to that of "Wonder," and the thin, flat, white seed of selected plants did not promise a good "shell" bean.

"Lightning-Six Weeks" (25/55). Both parents are early and the mother has a long, flat pod. Of the forty-nine plants grown, none equaled "Six Weeks" in pod quality.

"Lightning-Black Wax" (25/105). A wax variety with "Lightning" type of seed was expected in this cross. Fifteen plants of the first and fourteen of the second generation were under observation. Many bore broad, wax pods and were quite prolific, but they were found inferior to the "Black Wax" in quality. This cross is a good one for the study of heredity.

"Low's Champion-Longfellow" (27/26). The union of an early, good bearer with a short, flat-podded sort failed to produce any plants earlier or more prolific than "Longfellow."

"Refugee Green-Six Weeks" (36/52). The "Refugee Green," in itself, is a prolific plant, bearing round, stringless pods. Its union with "Six Weeks" could add nothing more than earliness. Ninety-four plants were under observation—thirty-one of the first, sixty-three of the second generation. Many plants possessed earliness; otherwise, no advance on the parents was made.

"Early Mohawk-Silver Bush" (31/38). This cross was well represented by thirty-five plants of the second generation and one hundred and ninety-three of the third generation. None of the offspring have borne white seeds and the pods are small, flat and stringy. The tendency to "run" was strong in the crossed plants.

"Six Weeks-Henderson's Black Valentine" (55/45). This is another case of combining two good varieties with no advantage gained in the offspring. An especially large number of plants represented this cross in the field—fifty-three of the first generation and four hundred and twenty-six of the second.

"Burpee's Brittle Wax-Lightning" (101/25). This cross offered a "Brittle Wax" pod with "Lightning" seed, but of the ninety-three plants grown, early and prolific as many were, their broad, flat pods were objectionable.

"Bismarck-Brittle Wax" (102/101). This combination represents a cross between a good "Black Wax" and one of the best round pod wax sorts. Thirty-five plants of the first generation and thirteen of the second were grown. Many round pods appeared in the first generation, but the flat pod of "Bismarck" prevailed in the second. Four green-podded plants were discarded. Many plants, though well-podded, did not excel the "Brittle Wax."

"Davis' Wax-Wonder of France" (111/52). This cross, between two long, flat-podded plants, one a white-seeded wax, the other a white-seeded green pod, has promised more from the standpoint of heredity than that of a new variety. A wax pod more slender than 111 was the only advantage apparent, an object already sought after in the promising cross of 11/101.

"Davis-Eldorado Wax" (112/152). This is a cross between two flat-podded varieties, both prolific and early. Eighteen plants of the first generation were grown and twenty-three of the second. The offspring bore long, flat, straight pods, not superior to either parent.

"Golden Crown-Flageolet" (125/114). The male parent is a round, wax pod, but the commercial sort often produces a flat, green pod. This may explain the appearance of large, green, flat pods in the cross. Thirty plants of the first generation were under observation and sixty-one of the second. The plants are rank growers, do not pod well and many

"run." White-seeded plants have been selected and have bred true, but the type is not a good one. The pods are large, flat, broad and coarse.

"Golden Crown-Lightning" (130/25). All the plants of this cross have the open, spreading growth of "Lightning," and, while early, are poor bearers with flat, stringy pods.

Novelties in Bush Beans.

Several commercial varieties of bush beans have been grown this season that are not in previous lists. Some of them are practically duplicates of former varieties, but each has a record number assigned to it.

Pods of the following varieties, as they reached full size, were gathered (July 20th) for museum specimens:

158. "*Silver Refugee.*" (Notes omitted for this variety last year are here added.) The plants are thrifty and in their foliage resemble "Refugee, Green" (36), with flowers purple, late bearing and prolific. The pods are long, slightly curved, round and like the "Crystal Wax" in color. A table test determined that this bean is of superior quality. It is being bred with the white-seeded varieties.

161. "*Everbearing Wax.*" This is a good, prolific "Black Wax" variety, with round pods and medium early.

162. "*California Pea*" (Green). The plants are of upright, open growth, with dark-green foliage and late pink flowers, short and plump pods, like "Low's Champion" (27), and seeds round and yellow, an unusual color in beans.

163. "*Eureka*" (Green). Similar to 162 in plant, flower, pod and seed.

164. "*Improved Black Wax.*" The plants are large, thrifty, with purple flowers and early pods, like the "Black Wax."

165. "*Perfection Wax.*" This is similar to 164. A promising, early variety, with purple flowers and black seeds.

166. "*Leopard Wax.*" A distinct type of plant, tall, with dark-green, broad, rough leaves; flowers pink, pods broad, thick and medium in length, and seeds curiously marked with black spots.

167. "*Mohawk Wax.*" The plants are large and thrifty, with enormous, broad, rough leaves; flowers pink, early; pods long, round, stringless, curved, and seed mottled.

168. "*Golden Refugee.*" The plants are of medium height and bushy, with foliage of the "Refugee" type, but smoother and of a more open growth. The late, prolific pods are between a green and a wax in color, long, round, curved, striped.

169. "*Keeney's Refugee.*" This is similar to 132 and 133 in plant, pod and seed.

170. "*King of the Wax.*" The plants are large, like the "Wardwell" (144); flowers pink, medium early; pods long, flat, curved, stringy; seed resembles the "Flageolet" (114).

171. "*Epicure Wax.*" This is a fine "Refugee" type of plant, with round wax pods; late, prolific; seed mottled. A table test found it to be of excellent flavor, tender and stringless. Its one defect is discoloration from the dark seed.

172. "*Prolific Everbearing.*" The plant resembles "Burpee's Brittle Wax," with flowers white; pods are early, long, round, straight, and seeds are white. Superior to the "Davis' Wax" (112).

173. "*New California Dwarf.*" This is another "Black Wax" type with purple flowers, and pods early, of medium length, rounding, curved.

174. "*Hardy Wax.*" This is a "Wardwell" type of plant, with flowers pink; early pods, of medium length, round, curved, stringless; seeds brown, mottled.

175. "*Lima Wax.*" The foliage resembles that of a lima; plant of medium height and compact growth, with white flowers; pods late, broad, flat, straight; seed white. A table test found this variety excellent in quality, with no discoloration.

176. "*Full Measure.*" This is a large, upright plant, resembling the "Wardwell Kidney" (144), with pink flowers; pods early, long, round, curved, stringless and green; seed mottled, brown.

177. "*Improved Tree.*" The same as "Prolific Tree" (34); flowers white.

178. "*English Stringless.*" The plants are large, with broad leaves, with pink flowers and a long, early, round, curved, stringless wax pod; seed brown, with dark eye.

179. "*French Stringless.*" This is a promising variety, which, like the "Longfellow" (26), bears its pink flowers and early pods above the foliage; pods long, round, slender, curved, green; seed mottled.

180. "*Triumph of the Frames.*" These are low, bushy plants, with small dark-green leaves and white flowers; pods very early, long, flat, curved, green, prolific; seed is white. This variety resembles "Wonder of France" (52).

181. "*Giant Forcer.*" This is another variety of the "Wardwell" type of plant, with pink flowers and medium-early, large, flat, long, curved, green, stringy pods; seed nearly white, with slight markings.

182. "*White Kidney*" (Green). The plants resemble the "Canadian Wonder" (8) and bear white flowers, and these are followed by long, flat, straight, green, late pods. Not a snap bean, but good when shelled.

183. "*Red Kidney*" (Green). The plants are similar to 182, but smaller and with pink flowers. As compared with "Canadian Wonder," it is earlier, with seed of a lighter red. Pods long, flat, curved, late.

184. "*Valentine Wax.*" The plants are small, with dark-green foliage, pink flowers; pods of medium length, round, curved, stringless; very early and promising; seed a mottled pink.

185. "*Hodson Wax.*" Plants of medium height and bushy, with narrow, dark-green, rough leaves, pink flowers; pods long, flat, curved, late; seed a mottled pink.

186. "*Giant Stringless*" (Green). Appears to be the same as the old "Giant Stringless" (46), with pink flowers and long, round, curved, early pods; seed light brown.

187. "*Black Marrowfat.*" These are low-growing plants with dark green leaves, purple flowers and long, flat, curved, stringy, late pods, not desirable for a snap bean; seed black.

188. "*Dutch Runner.*" This is a pole bean with large, flat, white pods, forming late and bearing white seed.

189. *"Broad Windsor."* This variety is often called "English Bean." In foliage and bloom it resembles somewhat the garden pea. The plants are tall and free-blooming, but set little fruit, due possibly to climatic conditions. The pods are short and round, with a husk like a pea when green and turns black at maturity.

190. *"Steckler's New Green Pod."* Large, bushy plants, with pink flowers; pods medium early, long, round, curved and stringless; seed mottled pink.

191. *"Pride of Newton."* This is an early green-podded variety, with sturdy, large-leaved plants and pink flowers; pods early, long, round, curved, stringless; seed light brown with a dark "eye."

192. This is not a commercial variety. It resembles very closely the "Prolific Tree' (34), but is earlier and more productive. These qualities may give it value in breeding.

193. *"Brown Bunch."* This is a late variety of spreading habit, white flowers; pods of medium length, flat, curved, dark green and borne in pairs.

194. *"Burpee's Stringless Green Pod."* The plants are large and of open growth, with pink flowers; pods early, round, curved, and seed is brown.

195. *"Hodson Green Pod."* The plants are striking in size and thriftiness, with large and narrow leaves and pink flowers; pods late, long, flat, curved; seed mottled.

196. *"Jones' Stringless Green Pod."* The plants vary in size from medium to large, with white flowers; pods of medium earliness and length, flat, curved; seeds white.

197. *"Pencil Pod Wax."* The thrifty plants are of open growth, with light purple flowers and medium-early, long, curved, round pod; seeds black. The "Livingston Pencil Pod" (148) has dark mottled seeds.

198. *"Boston Snap."* The name is the same as that of No. 3, but the plants have a more open growth and the flowers are pink, instead of white, and earlier in coming into bearing. The seeds are medium-sized and brown, while those of No. 3 are small and white.

199. *"Yellow Cranberry"* (Green). The plants are of medium size, bushy, with broad leaves and pink flowers; pods early, long, oval; seeds light brown.

Notes, with Engravings, of "Crystal Wax" Crosses.

The "Crystal Wax," with its attractive, pale silvery-green, fleshy pods, produced in profusion, and, bearing small white seed, promises to be one of the best varieties for breeding purposes. Of its seven combinations grown the past season, all except one gave a green pod in the blend; this is sufficient reason to consider the "Crystal Wax" a green-podded variety, at least as to its breeding characters. Five of the above crosses in their second generation show three types of pods, namely, green, "Crystal" and wax.

The blend of "Crystal-Bismarck" (145/102) produced pods strongly marked with purple, a character which was very prominent in the plants of the first generation grown in the greenhouse, and also seen in some plants of the second generation in the field.

The "Crystal-Chocolate" (145/11) cross had the green pod in the second generation, and selection for the "Crystal Wax" type is being made.

In the "Crystal-Burpee" (145/101) and "Crystal-Davis" (145/112) crosses a fine white wax pod is produced that may prove desirable to propagate. Plate XV. represents three plants of the "Burpee" cross, taken July 9th in the field row, when the pods were at a marketable stage. The plant to the left has the white wax type of pod with the form of 101. The middle plant, in foliage and color of pod, is quite close to the "Crystal Wax," while the plant to the right is green-podded and combines the forms of both parents.

"Crystal-Black Valentine" (145/45). The blend of this cross, grown in 1905, was a fine thrifty plant with an abundance of long, round wax pods. The seed was black instead of the usual mottled type, resulting from the union of plants with black and white seeds. A second crop of nine plants was grown the same season, some producing wax pods similar to those of the blend, others green pods resembling those of the "Black Valentine," but neither the "Crystal Wax" type of pod nor white seeds made their appearance. In the second generation, which was represented the past season by three hundred and thirty-nine plants, the same characters of the immediate parents prevailed without exception.

Plate XVI. shows a wax-podded plant in the center, and one with green pods upon the right, and another upon the left, as they stood in the field July 9th.

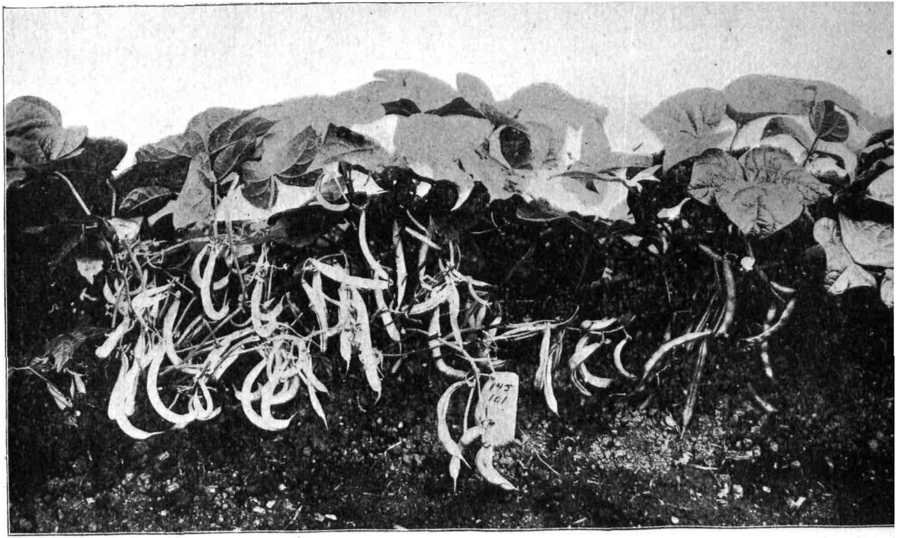
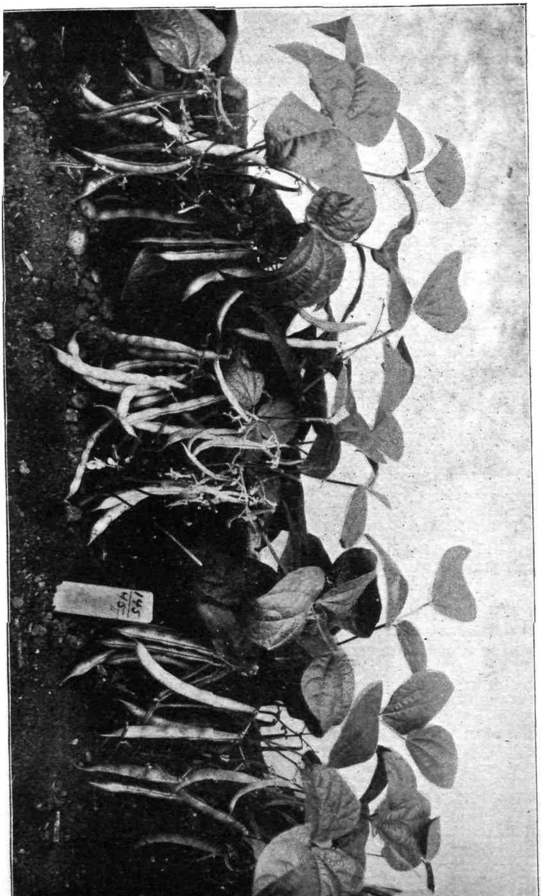


PLATE XV.



Spraying Experiments with Bush Beans.

Forty rows of bush beans were planted July 11th for the purpose of testing the value of spraying with standard Bordeaux to check the pod spot and rust upon late-grown beans. The record numbers from 1 through 146 are of old sorts, and the following, from 165 to 194, are among the novelties, that is, not before grown in the Gardens. The following is the full list:

1. "Best of All."
2. "Bountiful Bush."
5. "Burlingame Medium."
19. "Dwarf Horticultural."
20. "Dwarf Horticultural."
26. "Longfellow."
28. "White Marrowfat."
31. "Early Mohawk."
36. "Refugee" (Green).
40. "Mammoth Stringless."
45. "Henderson's Black Valentine."
47. "Red Valentine."
48. "Red Valentine."
54. "Six Weeks."
55. "Six Weeks."
101. "Burpee's Brittle Wax."
108. "Black Wax."
109. "Black Wax."
112. "Davis' Wax."
114. "Flageolet."
126. "German Black Wax."
127. "Golden Wax."
130. "Golden Eye Wax."
132. "Keeney's Refugee."
134. "Round Pod Kidney."
139. "Refugee" (Wax).
141. "Saddleback."
144. "Wardwell's Kidney."
145. "Crystal Wax."
146. "Yosemite Mammoth."
158. "Silver Refugee."
165. "Perfection Wax."
167. "Mohawk Wax."
182. "White Kidney" (Green).
185. "Hodson Wax."
194. "Burpee's Stringless" (Green).
195. "Hodson Green Pod."
196. "Jones' Stringless" (Green).
197. "Pencil Pod Wax."

The first spraying was given upon July 19th, eight days after planting, and a half of each row was left untreated with the Bordeaux throughout the experiment. While the plan was to spray at intervals of one week, the rainy weather required some modification so that the dates of the seven sprayings were as follows: July 19th and 23d, August 1st, 4th and 13th, September 1st and 8th.

There was very little disease of any sort, in some measure due to the unusually fine seed employed. The varieties, which showed a small amount of pod spot, were the "Six Weeks," "Black Wax," "Davis," "Golden Eye" and "Saddleback Wax," and those with more of this disease in evidence were "Flageolet," "Golden Wax," "Mohawk," "Burpee's Stringless" and "Pencil Pod Wax." The kinds not mentioned above were comparatively free from the pod spot.

The rust appeared later and only in small amount upon the following varieties: "Longfellow," "White Marrowfat" and "Refugee," thus indicating that the late green-podded sorts may be the more susceptible.*

The foliage held upon the plants longer with some of the sprayed half rows than those which were untreated, but, as a whole, the test showed no practical benefit from the application of the Bordeaux mixture because of the general absence of the diseases that were to be combatted.

"Natural Suspect" Beans.

The term "Natural Suspect" is given to those apparent crosses which have occurred without previous treatment of the bloom to secure a special combination. That varieties of lima beans may mix without the aid of artificial pollination, when grown near together, and presumably through the agency of insects, is inferred from the results obtained in the case of the "Jackson Wonder" crosses.

For several years many varieties of snap beans have been grown in parallel rows uniformly two feet apart. Last year, when the first crop was gathered from a planting of these home-grown seeds, beans were found in certain rows different, not only from the parent type, but unlike any other variety in the plot.

Below are given some of the varieties which produced divergent seed types with the varying color in each case:

The "Black Valentine," "Cylinder," "Burpee" and "Davis" all gave the dark-mottled seeds as a variation from the parent type. From the "Jones' Stringless" row curious gray-mottled seeds with a dark "eye" were gathered.

The "Black Valentine" "suspect" in the second generation produced seeds of three types—black, mottled and that of the "Burpee." Judging from the behavior of "hand-worked" crosses, this result points to a mixture with a black-seeded sort like the "Bismarck," which was grown two feet from the "Black Valentine."

---

*NOTE—The "Tennessee" and "Improved Tree" (both green-podded) grown as a second crop elsewhere in the Gardens, rusted quite badly but did not show the pod spot.

The "Davis" "suspect" gave in the second generation mottled and white seeds, while "Jones' Stringless" produced a dark brown in addition to the gray-mottled type.

So much attention was demanded by the more important "hand-worked" crosses that little time could be given to the "Natural Suspects" during the past season, but seeds have been saved for a further study of the subject.

Mature and Immature Beans for Seeds.

Upon July 20th, immature beans, freshly gathered and still quite soft, were planted with every alternate parallel row, receiving mature stock seeds of the same variety.

The object of this experiment was to observe any differences which might thus occur between the pairs of rows.

Of the eight varieties thus treated, "Bismarck," "Allan's Imperial," "*Eldorado*" *and* "*White Kidney*" *showed no contrast in* size of plant, earliness, prolificness or color of seeds.

With the "California Black" and "Davis" the immature row was the more prolific, but the opposite was true of the "Improved Tree" and "Pride of Newton."

The experiment does not show that there is much difference to be expected between the crops obtained from planting freshly-gathered seeds and from thoroughly dried commercial beans.

SCARLET RUNNER HYBRIDS.

Early last year hybrids were secured between the "Scarlet Runner" (*Phaseolus multiflorus*) and several snap bush beans (*P. vulgaris*). The differences between the parents are great, for the former is a climbing species with a profusion of blooms of a bright red (scarlet) color followed by an occasional pod bearing but few large chocolate and purple-mottled seeds, and the latter is a bush or dwarf type of the common garden bean, the particular characteristics of which are given below under the varieties that are involved in the union.

"Scarlet Runner-Tennessee" Hybrids.

The "Tennessee" is a variety of bush bean that is taller than the average of its class, bearing white flowers and long, flat green pods that produce seeds of medium size and of a light brown color. The seeds obtained from the blend late in 1905 were uniformly of a size and shape midway between the two parents and with nearly the same markings as the male parent ("Scarlet Runner"); from these seeds the present crop has been grown. In the accompanying plate, XVII., the lot of seeds that most nearly matches the blend is shown at 9. A set of thirteen piles of the first generation of the hybrid is shown from 2-14, seeds of the male parent being given at 1 and of the "Tennessee" at 15. The blend seeds were planted May 1st, and the several plants and their crop of seeds are considered in the following paragraphs:

No. 1. The first plant in the row of hybrids was of the bush type, medium-sized, with purple flowers, the seeds of which (shown at 2 in the plate) were all uniformly of the size and shape of the "Tennessee," and were solid, dark purple, looking black at a little distance.

No. 2. This was a small, early-fruited plant, the produce being only a few seeds (shown at 3), the beans having a yellowish-brown color, with a fine, indistinct mottling. There was very little in these seeds to suggest the "Scarlet Runner" parent.

No. 3. This was a small, early-maturing plant, which gave a very handsome type of seeds (shown at 4), the plumpness of which exceeded that of either parent, and in markings is quite unusual. The beans were nearly four-fifths black, with small, irregular patches of white in the area most distant from the "eye." The bright, shiny coat is in striking contrast with those of the two previously-mentioned numbers.

No. 4. This was a large, wide-spreading plant, with red flowers and dark green, curved pods. It was the most prolific member of this set and its type is shown at 5. The seeds here were very variable in size, and, being borne close to each other in the pods, have their ends of a peculiar angular form. Still more extraordinary is the color, which is a gray, with fine, bluish mottlings, becoming darker near the "eye." They do not suggest either parent and appear like a new departure in beans, the worth of which remains to be demonstrated.

No. 5. This was a medium-sized plant with red flowers and flat pods, curved and striped. The seeds were decidedly flat, after the "Tennessee" type, while the color and markings only faintly suggested the "Scarlet Runner." The background is gray and of a dull purplish red, somewhat concentrically arranged around the "eye." At 6 some of the seeds are much lighter colored than others—in fact, a few are nearly solid dark colored, as shown in the engraving.

No. 6. This was a small, bushy plant, with medium-sized pods, and at once reminded one of the "Scarlet Runner" in the color and markings of the seeds, but in size and shape it closely approached the other parent. The dark purple appears as black and the light portions shown are due to the reflected light from the shiny surface. Seeds are shown at 7.

No. 7. This was a small plant, closely resembling the "Scarlet Runner" in flower, foliage and seeds, but was a true dwarf, with a long blooming period, yielding short, flat, broad pods. The small quantity of seed secured (shown at 8) are above the average in size, and in shape and other markings closely resembled the "Scarlet Runner." Three seeds of this lot were planted in the greenhouse on August 27th and all are of the bush type, with red flowers.

No. 8. This was a medium plant, with short, flat pods, the seeds of which are shown at 9, and might well be mistaken for the blend originally obtained. These beans are medium-sized, flattish and marked with peculiar purples, dark and light, that are so characteristic of the "Scarlet Runner."

No. 9. This closely resembled No. 4, being a large, spreading plant, after the type of the "Scarlet Runner," with dark stems and foliage, with purple flowers and bearing a large number of flat, striped pods throughout a long season. The seeds, making the second largest group (shown at 10), are of good size and shape and uniformly of a dark purple color, appearing almost black.

No. 10. This was a small, early-maturing plant and strikingly different from the last in many respects, not the least being the appearance of the seeds as shown at 11, which were closely mottled and quite long and flat. The basal color is that of the "Tennessee," the somewhat concentric blotches being of a purple color. These markings are fairly-well shown in the engraving.

No. 11. This was also a medium plant, with pink flowers, medium-sized, flat, striped pods, the seeds of which (shown at 12) are longer than the average and of a dull, dark purple, with indistinct mottlings. When immature, the "Scarlet Runner" characteristics were more in evidence.

No. 12. This was a medium-sized, early-maturing plant, with red flowers, followed by short, flat pods. Its crop of seeds is shown at 13, consisting of attractively odd-looking beans, the basal color seal brown (approaching the "Tennessee"), but much mottled with a darker color.

No. 13. This was a plant with a long stem, inclined to twin, bearing white flowers and flat pods. The seeds, very few in number (shown at 14), were long and peculiar in having one end entirely white and the remaining portion pure, dark purple.

The thirteen plants, the seeds of which are figured, were divided into three groups, as follows: Small, five; medium, five, and large, three.

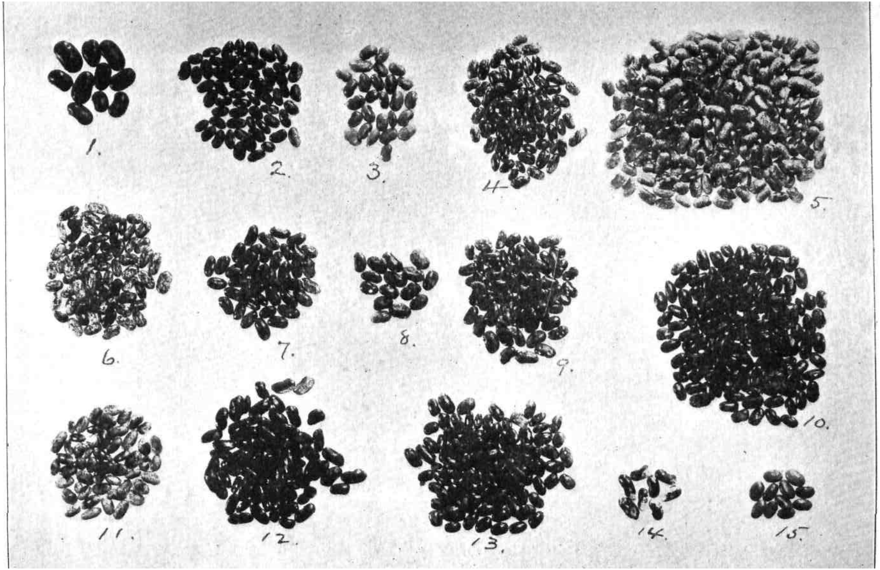
"Scarlet Runner-Six Weeks" Hybrids.

There were seven plants grown of the hybrid between "Scarlet Runner" and "Early Six Weeks" (63/53). The plants were all of the bush type, and two had red, three purplish and two white blossoms. The parents have scarlet and pink flowers, respectively, and the white flowers might not be expected. In shape of pod there was some variation in the length and breadth, but all were curved. Three plants had black seeds and the other four showed strongly the "Scarlet Runner" parentage in being dark mottled. The lack of inclination to "run" was manifest, and seems to indicate that the "Six Weeks" has a preponderating influence in determining the size and habit of the plant. It is not easy to account for the large percentage of black-seeded plants, for the mother plant bears light brown beans.

GENERAL NOTES UPON BEANS.

Earliness is associated with a quick-growing plant of open growth, while a late variety is usually spreading in habit, of a denser foliage, and produces more pods. The "Golden Wax" is a good example of an early variety, and the "Triumph of the Frames" is an early green-podded sort, popular for forcing.

Three types of plants are readily distinguished in the bush beans, the "Dwarf," "Standard" and "Running." Small, low-growing varieties like the last two mentioned belong to the first


1.
2.
3.
4
5.
6.
7.
8.
9.
10.
11.
12.
13.
14.
15.

group. The tall bush sorts, like "Canadian Wonder" and "Burpee's Brittle Wax," may be classed as "Standards," forming the largest group, while the smallest is the "Running," and includes such sorts as the "White Marrowfat;" these varieties seem to form an intermediate type between the true bush and the pole bean.

Two distinct leaf types with intermediates are apparent, the *broad, short, and the long, narrow* leaf. "Wardwell's Kidney" is a good example of the first and "Keeney's Refugee" of the second type. There are also marked differences in leaf suface, whether smooth or wavy.

The plant stem, as well as the foliage, may be either a light or a dark green. A dark stalk indicates a dark-seeded parent, while a light green stalk is evidence that a white or a light colored bean has been planted.

From the color standpoint there are four types of flowers, namely, purple, pink, striped and white. The striped form seems to be rare among beans, since but one variety with that color, the "Lightning," has been grown at the Gardens. A purple flower is associated with a black or dark-colored seed; a pink blossom with a seed between the dark and the light, as the "Yellow Six Weeks," and the white flower with either a white or a light-colored seed.

Flat and round pods occur in both the green and wax varieties. The round pods have the preference because associated more with stringlessness.

Variations of the green color are the dark and the light shades with some sorts, like the "Goddard," having on the surface stripes or markings of a deeper color. The "striped" pod usually indicates a mottled seed, and may be of either the green-podded or wax type. The striped form does not appear until the pod is nearing maturity, a characteristic, for example, of the "Keeney's Refugee." The silvery-gray pod, like that of the "Crystal Wax," is another peculiar variation of the green. In the true wax beans there are the "white" and the "golden" types.

Of nine assured crosses between a white and a black-seeded variety, all gave plants in the blend bearing mottled seed. Furthermore, the red and white-seeded varieties, when united, gave a mottled seed in four and the brown and white in two instances, and the crossing of a white-flowered variety with one having a purple flower gave a purple flower in the first generation, and a green-podded united with a wax sort results in a green pod in the blend.

EXPERIMENTS WITH SQUASHES.

During 1905 thirty-three crosses of summer squashes, secured in 1903 and 1904, were grown, a full account of which, with a plate, were given in the report for last year (pages 492-497). The seeds from forty of the selected fruits of that crop were used for planting the present season. Each lot of seeds was given a separate row across a plot and containing eight hills, four feet apa The stand of plants was satisfactory excepting in one row, wh was replanted from another lot of seeds.

Some of the rows were planted with seeds that resulted fr fruits grown after pollination within the plant, and these designated by the letters C. F. (close fertilized) in the followi record, while the others, being fertilized within the row, are tinguished by the letters W. R. Stakes were lettered from A. N.N. to avoid confusion in the reference to the row in the pre ous year, thus: A, 5/6, type 8, C. F. I., means that in the fi row seeds were planted from a rectangular, warty squash (type fertilized within the plant bearing the fruit (C. F.), and of cross of "Yellow Crookneck" upon "Long Island Scallop" (5/ The Roman numeral indicates the row (I) from which the "ha worked" fruit was selected in 1905. The following types squashes have been determined and correspond with the engr ing in the report for last year above cited:

1. Flat, smooth, not scalloped.
2. Flat, warty, not scalloped.
3. Flat, smooth, scalloped.
4. Flat, warty, scalloped.
5. Rectangular, smooth, not scalloped.
6. Rectangular, warty, not scalloped.
7. Rectangular, smooth, scalloped.
8. Rectangular, warty, scalloped.
9. Oval, smooth, not fluted.
10. Oval, warty, not fluted.
11. Oval, smooth, fluted.
12. Oval, warty, fluted.
13. "Jug," smooth, not fluted.
14. "Jug," warty, not fluted.
15. "Jug," smooth, fluted.
16. "Jug," warty, fluted.
17. Longneck, smooth, not fluted.
18. Longneck, warty, not fluted.
19. Longneck, smooth, fluted.
20. Longneck, warty, fluted.
21. "Cheese," smooth, not fluted.
22. "Cheese," warty, fluted.
23. Spherical, smooth.

The classification assumes that the flat, smooth unscalloped fruit is simplest general type of squash, and the long, warty and fluted one the m complex. Three forms are given after the classified groups.

A. 5/6, type 8. C. F. I. There were thirty-three fruits, chiefly cream colored and flat, the leading types being 4 and 8, small and early.

B. 5/10, type 22. C. F. III. Forty-seven fruits, cream colored, flat, types 22, 3 and 16.

C. 5/12, type 6. C. F. III. Forty-five warty fruits of an orange color and somewhat variable shape around the type 14.

D. 5/12, type 22. C. F. IV. Sixty-two fruits, chiefly cream colored, of types 22 and 11.

E. 5/6x5, type 15. C. F. VI. Sixty-one yellow-orange fruits, many striped and of types 21, 3 and 13.

F. 5/6x5; type 15. W. R. VI. Fifty-five fruits, varying in color from white through orange to green, many striped. In shape they were quite evenly divided between flat, jug and long-neck form and with a small amount of wartiness.

G. 5x6/6x5, type 18. W. R. VII. Forty-four fruits, all of yellow-orange color and the parent type (18).

H. 5(6x5)5(6x5), type 16. C. F. IX. Thirty-eight fruits, quite variable in color, some dark green but in shape generally the parent type with only a few warts (13).

I. 5(6x5)5(6x5), type 16. W. R. IX. Thirty-three fruits, agreeing quite closely with the previous row. The record for last year shows that the prevailing type then was as it is now and is becoming fixed.

J. 5(6x11), type 16. C. F. X. Only twenty-one fruits, varying in color, types 11 and 3.

K. 5(6x11), type 18. W. R. X. Fifty-one yellow, warty fruits of the parent type (18).

L. 5(6x11), type 10. C. F. X. Only twenty fruits, chiefly yellow, with the types 14 and 10.

M. 6/5, type 16. C. F. XI. Forty-eight variable fruits in color and shape, many striped and some nondescript. The leading types are 16, 17, 10 and 6.

N. 6/5, type 16. W. R. XI. Thirty-seven variable fruits, cream, yellow, striped in color, and in shape types 16 and 18.

O. 6/9, type 3. W. R. XII. Forty-six fruits, chiefly white-cream in color and flat with scallop (type 3).

P. 6(5x6), type 3. C. F. XIII. Forty-three white fruits of type 3. An early and uniform row.

Q. 6(6x5), type 16. C. F. XIV. Thirty-six fruits, all white, with the general form of types 13 and 7.

R. 6(6x5), type 11. W. R. XIV. Thirty-eight fruits, all white, but variable in shape from type 1 and 3 to 21 with several *not easily classified.*

S. 6x5/5x6, type 15. C. F. XV. The forty-three fruits are small, usually striped with yellow and of the parent type (15).

T. (6x5)6x5, type 1. C. F. XVI. The fifty fruits vary in color from white to yellow with some striped and in shape are between type 1 and 21.

U. 6x5/6x5, type 20. W. R. XVI. The thirty-seven medium-sized plants have a wide range of colors and shapes, approaching most nearly the types 14, 17 and 15.

V. 6x5/11, type 16. W. R. XVII. The forty-nine large, *medium-early, warty fruits while largely white showed cream,* yellow, orange and various stripes. The forms range from flat to "cheese" and longneck.

W. 6x5/11, type 20. C. F. XVII. The fifty-seven warty fruits had a great variety in color, but the shape was quite close to the parent type (20).

X. 8/5x6, type 10. C. F. XIX. The fifty small, yellow fruits were quite close to the type 15, many, however, being distinctly "jug" like the parent.

Y. 8/12, type 3. C. F. XX. The sixty-two large, early fruits *were all white, smooth and strictly of type 3.* This was the most uniform of all the rows.

Z. 9/6x5, type 8. C. F. XXI. The thirty-six small, nearly smooth, fruits were of the yellow group of colors and of types 7 and 8.

A.A. 10/11, type 16. C. F. XXII. The fifty-nine medium-sized, somewhat warty fruits showed a wide range in color and in shape ranged somewhat from the parent type (16) to 14 and 17.

B.B. 10/11, type 22. W. R. XXII. The sixty early, medium-sized fruits were in large part white or cream colored, but some were yellow-orange and nondescript. The shape varied from flat to "longneck," while others were "jug" or "cheese."

C.C. 10/6x5, type 3. C. F. XXIV. The fifty-eight medium fruits were largely white and flat, adhering closely to the parent type.

D.D. 10/6x5, type 18. W. R. XXIV. The forty-nine warty, medium-early fruits were half yellow and the other portion white, cream and orange. The shape was that of the parent type (18) with few exceptions.

E.E. 11/9, type 8. C. F. XXVI. The forty-two large, early, warty fruits were chiefly orange colored and in type close to the parent (8).

F.F. 11/10, type 16. W. R. XXVII. This was a very variable row, the thirty-five medium-sized, warty fruits representing all squash colors excepting green.

G.G. 11/6x5, type 8. W. R. XXIX. The forty-eight medium-sized, early, warty fruits represent all squash colors, and in shape vary from flat to longneck, the parent type prevailing.

H.H. 11/6x5, type 16. C. F. XXIX. The yellow color predominated in the sixty-five medium, warty fruits. In shape, the two leading types were 6 and 16.

I.I. 11/6x5, type 16. C. F. XXIX. (Failed.)

J.J. 12/11, type 8. C. F. XXXI. The fifty-one small, warty squashes were all yellow or orange, like the parent fruit. In shape, there was a range from flat to "jug" and longneck, the type 8 being quite common.

K.K. 12/5x6, type 4. C. F. XXXII. The fifty-five medium, warty fruits were largely white or cream-colored, like the parent fruit, but some were orange and a few dark green. The type 4 included nearly all the species, a few being "jug" or "cheese" shaped.

L.L. 12/6x5, type 4. W. R. XXXIII. The forty-nine nearly smooth fruits were a half white or cream, like the parent, and many of unusual mixture. In shape, the fruits were about half of the type of the parent (4).

M.M. 12/6x5, type 4. C. F. XXXIII. The fifty-three fruits were mostly white, but in shape there was more variation, type 3 being the leading one.

N.N. 13/11, type 8. C. F. XXXIV. The sixty large, late fruits were all orange-yellow and long-necked, type 18.

There were twenty-five rows of plants that are marked C. F., indicating that the seeds used were from close-fertilized fruits, while fourteen rows were with plants that came from squashes resulting from a union of two plants within the row (W. R.).

The total number of squashes in the C. F. rows was 1,195, giving an average of 48.

From the W. R. rows the total was 631, making an average of 45 squashes per row.

From this is it seen that there is no marked difference in the yield between wide and close fertilized crossed squashes.

The "Jug" Type of Squash.

One of the forms of fruit that came at once prominently to view in the offspring of the cross of the "Crookneck" upon the "Scallop" in 1904 was that with a comparatively long axis and a short neck, which has led it to be spoken of as the "jug" form. It was figured two years ago (1904, Plate IV.), along with the parents, and also in the report for 1905, numbers 13 to 16, in Plate XI., where the various types of summer squashes are figured. As this seems to be a desirable type to fix, Plate XVIII. presents thirty-nine fruits from the crop for the present year. Several plants having the "jug" type of fruit have been "hand-worked" within the plant, and from the resulting fruits seeds have been saved for future planting.

It is observed that the shape varies greatly within the general type, but the greatest range is in color, which extends from the white, shown in several (at 10 and 20), through the yellow, orange and variously striped (6 and 9) to solid green (3 and 16). The warts are not much in evidence, and from the experience of the past few years it seems likely that smoothness of surface is a character that it is not difficult to secure by selection. The aim is to obtain a strain free from warts with a broad base and straight neck (2, 8 and 14) in the white (cream), orange and solid green colors, and at least one with the particularly attractive orange striped upon a white or cream background, specimens of which are shown at 6 and 13 in the engraving.

A more essential point in summer squashes than shape and color is earliness, which there are hopes of gaining by breeding and selection, and without loss of productiveness, which is, of course, the main desideratum. In all the squash work the attempt is being made to reduce the seed cavity to a minimum, and therefore thicken the "meat" of the wall of the fruit. In summer squashes this is perhaps not so essential as with winter sorts, the entire fruit being used, with the possible exception of the skin.

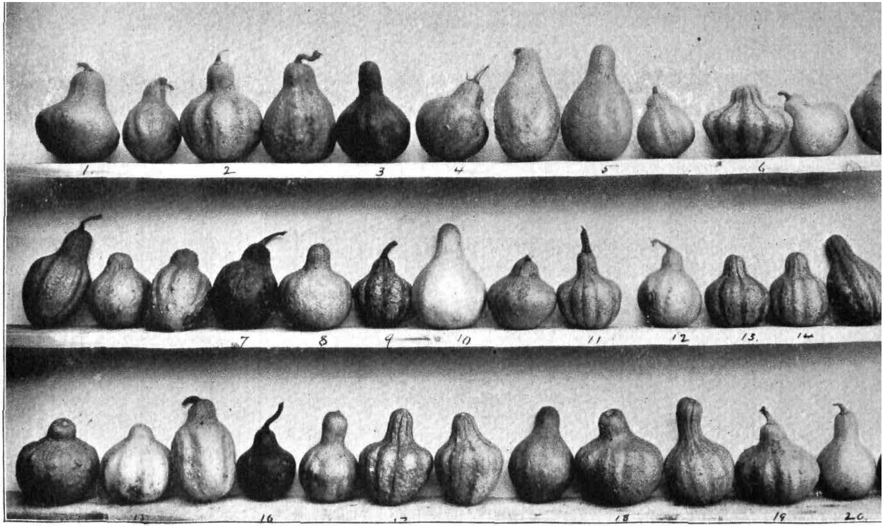


PLATE XVIII.

Crossed Squashes. The "Jug" type of Summer Squash, resulting from the breeding of the "Crookneck" upon the "Scallop," with various colors and stripes.

Growers' Notes upon Station Summer Squash No. 1.

Packets of seeds of a cross of "Crookneck" upon "Scallop" were distributed to eighty-two persons requesting them, and below are some of the remarks received from those making the test: "Summer squash is a vigorous grower and the fruit of uniform and medium size." "Plants all very healthy." "Quality good; planted May 3d, fruited June 26th, and bore well up to August 10th." "A rank grower and very productive; extra early." "Satisfactorily productive." "Quality very good; plants vigorous and spreading; planted April 30th (indoors) and transplanted May 17th; first squash ripened July 20th." "Plants grew well and yielded well." "I cannot speak too highly of the 'Station Summer Squash;' in size, the longest I have ever grown; vigor and productiveness exceeded all expectations; shape, with one or two exceptions, perfect; color, white; uniformity and quality of fruit left nothing to be desired; it is the quickest grower I have ever seen." "Was a heavy bearer and good size, and very fine for pies; the bugs did not bother this plant, while they nearly destroyed the other kinds." "Quality of all used thus far has been good." "The squashes are doing very well." "One hill of the row seeded with seed received from you produced a large bronze-striped squash, of somewhat the pineapple shape; these I found ideal and have left to mature for seed; I think it is established as a variety, as all on the hill were always alike." "Squash was extra fine." "Vigorous growers and very productive; quality good." "Plants were very thrifty and productive." "The summer squash grew quickly; was and still is very vigorous, and productive of fair-sized fruit, which keeps tender longer than the common scallop kind." "They are all fine eating squashes and are very productive, having four to five on a vine."

EXPERIMENTS WITH WINTER SQUASHES.

Limited space prohibited the planting, with the exception of the "Japanese," of other than crosses among the vine squashes. The list that follows is arranged according to the numerator of the record fraction used in the field notes, beginning with one (1/2) and ending with 30 (30/2). Each row in the Garden proper

occupied a row across a plot and consisted of five hills, nearly six feet apart in the row. Those upon the New Land consisted of four hills each, similarly arranged, and included all the crosses from K to X, letters being found less confusing than figures for stake marks and headings for notes in the record book:

A. *"Hubbard-Boston Marrow"* (1/2). The seeds used were from a striped orange and green fruit. The vines were vigorous, but showed some variation in this respect. Upon September 25th, the harvest showed fifteen marketable fruits, three of which would pass as true "Hubbard" squashes; eight were pea green, striped, large, and one bright orange. Two upon one plant were of a salmon color and are shown at 1 in Plate XIX. These agree in shape with the "Hubbard" type and may become the starting point of an attractive and superior strain of winter squashes. The pair shown at 3 were taken, along with one other fruit, from the same plant, and indicate that crosses between distinct varieties may be prolific.

B. *"Hubbard - Boston Marrow - Delicious - Golden Hubbard"* (1/2//3/4). In this combination of four varieties of standard squashes, the first two have much larger seeds than the others and in the cross the fruits bear the two sizes of seeds. Therefore, in the present instance, the planting was with the smaller seeds. The five hills produced a very vigorous set of plants that bore a remarkably variable lot of twenty-three fruits—some of them of great length and of a bright orange color, and others of a pale green and a few mottled. The disadvantage of combining four "bloods" is apparent, and the feeling of abandoning the medley is uppermost. If one seeks for varied types of winter squashes, he may well grow this combination, but to get a fixed type out of it looks hopeless. Five fruits are shown in the lower row of Plate XX.

C. *"Delicious-Hubbard"* (3/1). This cross produced a fine, even set of plants, bearing twenty-one marketable fruits, all green, but varying in the markings and general shape. The middle view in Plate XIX. shows a surface view of four of the fruits of the cross and a fifth in section. The "Hubbard" is more in evidence in the shape than the "Delicious," but in the specimen, at 6, is one quite like the "Delicious," both in shape and the flecks of lighter color, that are quite attractive. This same indication of the cross is seen in many of the fruits, as at 4, that are otherwise closely of the "Hubbard" type. From such as these the cross will be continued.

D. *"Delicious-Golden Hubbard"* (3/4). The plants were de-

sirable and the twenty-one fruits of a good form, samples being shown at 7, 8 and 9. Nearly all of the squashes were solid dark red-orange, showing the greater strength of the "Golden," but one was green throughout, and five showed a mixture of green with the prevailing orange. Some of the fruits were quite long, and, as a rule, the neck was evident, the shape of the "Delicious" being controlled by the "Golden Hubbard."

E. *"Delicious-Bay State"* (3/21). The "Bay State" has a somewhat cheese-shaped fruit of a bluish green color, and therefore the prevailing color of the cross was, as expected, a rich light green, to which the flecking (due to the "Delicious") added an attractive marking. In size the squash is medium and in shape flat, without the angularity of the "Bay State." A sample of the thirty fruits is shown at 5, Plate XX., and a section of another at 6. The flesh is of a desirable rich orange-green and the quality superior, and in keeping qualities it is also very promising.

F. *"Golden Hubbard-Hubbard"* (4/1). The plants of this cross did not do well and only a few reached the bearing age. One of the largest squashes of the season was produced here, "Hubbard" in shape and blotched with green and orange. There were eleven marketable fruits in all, varying in markings from solid green to those that were nearly pure dark orange, and, in shape, generally longer than the "Hubbard," with the prolonged, free and curved tip.

G. *"Golden Hubbard-Boston Marrow"* (4/2). The plants were feeble and many of them perished early in the season. Only two fruits were obtained, both orange, and closely adhering to the "Golden Hubbard" form—that is, long and pointed.

H. *"Golden Hubbard-Warren"* (4/7). There was a poor stand of plants and the soil was not favorable for squashes. Only three fruits reached maturity, two of which were shaped somewhat like the "Warren" (cheese), somewhat ribbed and having green stripes upon an orange background, excepting at the blossom end. The navel of the "Warren" was somewhat in evidence in sectional view, which also shows a fine, thick flesh. Two of the fruits of this cross are shown at 1, in Plate XXI.

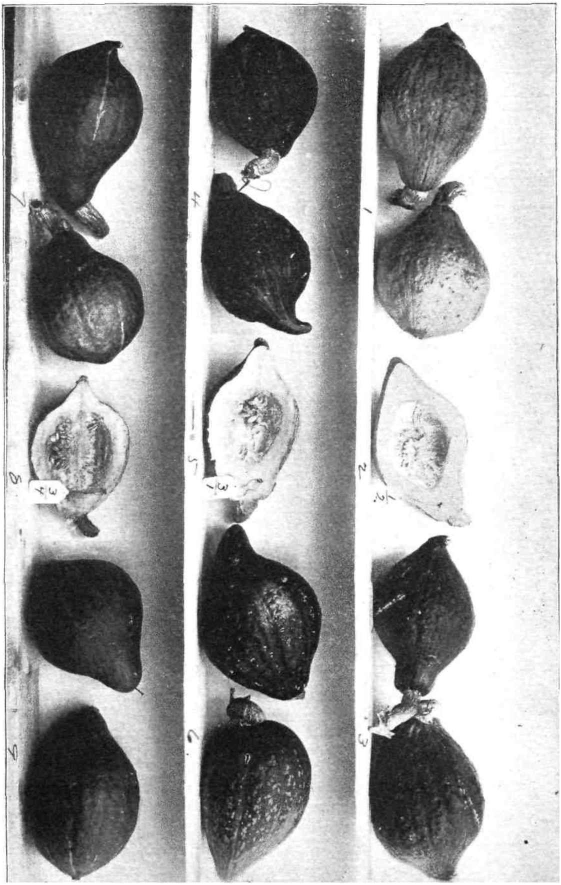
I. *"Golden Hubbard-Faxon"* (4/30). This row showed so few seedlings that the hills were replanted upon July 6th, and from the latter some quite large fruits were obtained, there being a total of fifteen, all solid, bright orange and resembling the male more than the mother parent. The "Faxon," as grown last year, gave a small, nearly smooth, flattish fruit, with the stem set upon the smooth upper end, and this form of stem was evident in the cross,

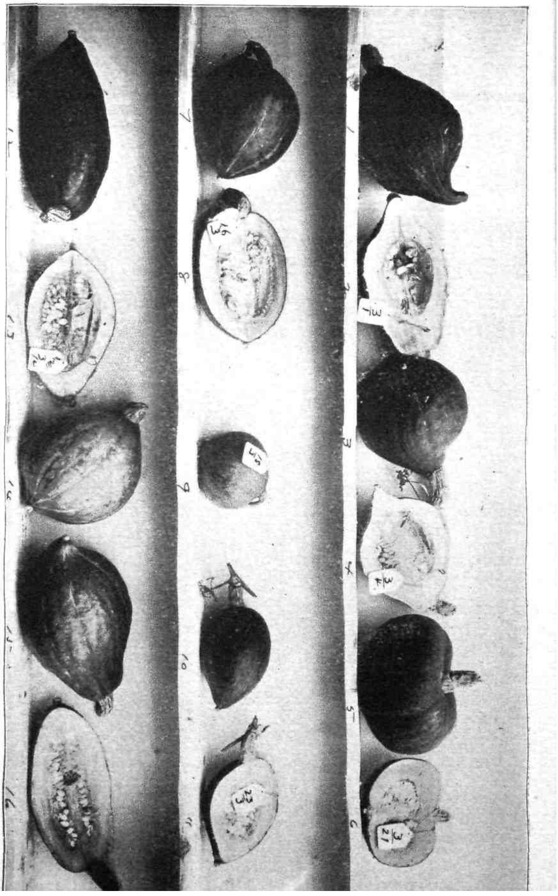
giving the general shape of the "Delicious" to the fine, smooth, orange fruits. The flesh is uniformly of the same color as the surface and with abundant large, white seeds. The keeping qualities were not good, but the fruits were perhaps not fully matured at harvest time, owing to the replanting and shortened season.

J. "*Warren-Boston Marrow*" (7/2). A few plants were especially vigorous, but the majority were overtaken by the stem grub and perished. There was a replanting upon July 6th, from which a dozen marketable fruits were obtained, but were not sufficiently mature for seed-saving. The best hill of the original planting gave eight fruits, all of the same color (cream-orange), quite like the "Boston Marrow," and in shape a blend of the "cheese" of the "Warren" and the broadly obovate of the "Marrow." Of the twelve fruits suitable for seed-saving, five showed a well-defined navel and seven none, but the latter had a flat blossom end, unlike the "Marrow" type, and there was therefore not a uniform blending of the two forms of ends above mentioned.

K. "*Warren-Japanese*" (7/31). This, and all the following crosses, were grown upon the New Land, and had less favorable conditions than obtained upon the Garden proper. The vines were slow in getting a start, but finally made a large growth and covered the ground. At harvest, upon September 25th, thirteen fruits (all of good size) were secured, two of which are shown at 5 in Plate XXI. Nine of the fruits were orange colored, considerably ribbed and of the shape shown in the left one of the pair at 5. By comparing this with samples of the "Japanese," shown at its left (30), it is seen to be much larger, less ridged, not sunken at the stem or blossom end, and with the stem long and comparatively slender, like the mother parent. Three of the crossed fruits were quite nearly like the "Japanese" in general outline, and one, shown at 5, was nearly green and smooth, and having an unusually long stem. In sectional view the fruits all showed a medium-thick flesh and an indication of navel in the grain, and coloration of flesh at the blossom end in eight, while four had a distinct navel showing upon the outside. These little plants had but few plump seeds and these were all of large type, similar to the "Warren," but lacking the white color of the latter. The seeds in the fruits of the "Japanese" type were numerous and small.

L. "*Japanese-Mammoth Chili*" (15/16). Eight fruits of marketable size were obtained from this set of hybrid squashes, six of which were solid dark green and two entirely orange, and in shape uniformly oval and somewhat ribbed, two samples of which are shown at 6. The largest orange fruit had a thickish flesh of the





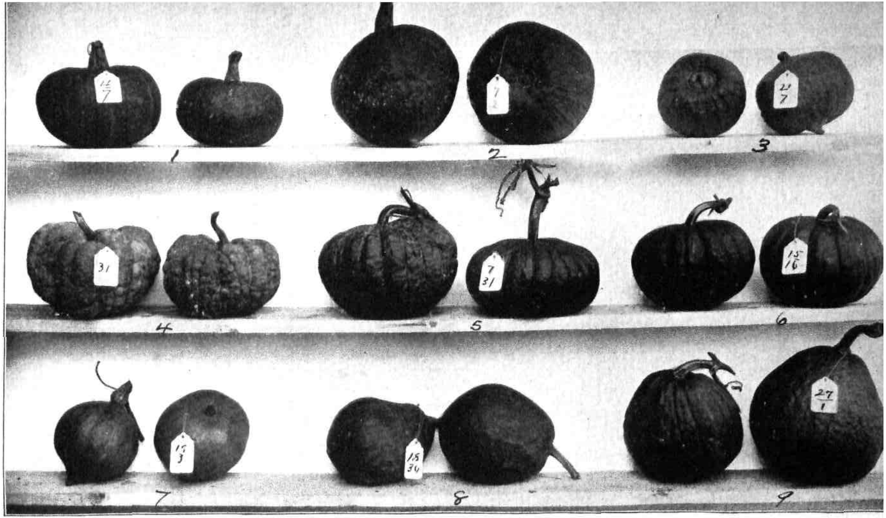


PLATE XXI.

Crossed Squashes. The upper row contains three crosses with the "Warren;" the middle row those with the "Japanese" sort, and in the lower are those with t[illegible] "Winter Crookneck" and "Canada Crookneck" upon "Delicious," "Faxon" and "Hubbard."

same color as the exterior and a strong "pumpkin" odor when opened, showing a large, nearly empty, seed cavity. Only an occasional plump seed was met with, among them many that were full-sized were empty.

M. "*Mammoth Chili-Delicious*" (16/3). Only three fruits of this cross were obtained, two of which are shown at 7 and 8, in Plate XX., and all pale green, with indistinct stripes. The shape is the peculiar obovate (spade) form of the mother parent, but evidently the fruits would attain to much larger size under favorable conditions. The seeds, produced in abundance, were in size midway between those of the two parents. For its pleasing pea-green color, handsome markings, attractive shape and thick golden flesh, this cross offers much of promise, provided the table and keeping qualities equal those of the mother.

N. "*Mammoth Chili-Japanese*" (16/31). This, from all points of view, seems to be fully "Japanese," there being some possible error yet undetermined.

O. "*Winter Crookneck-Delicious*" (18/3). The harvest from this cross was exceedingly meager, there being only three small fruits, all of a pink-cream color with pale green markings. One of these fruits is shown at 9, in Plate XX., and two at 7, Plate XXI. The shape is seen to be a broad one, with a pointed blossom end with the stem medium stout. The flesh is only of average thickness, of a dull orange, with a green streak near the surface. There was an abundance of seeds, which were larger than the dull, white male parent and smaller and less "chalky" than the mother.

P. "*Winter Crookneck-Faxon*" (18/30). Here, again, the crop was small, no doubt due in large part to the unfavorable conditions of the soil. The crop consisted of eight medium-sized fruits, two of which are shown at 8, Plate XXI., and all were light orange with a handsome, fine netting of a darker shade of orange. In shape the fruits varied slightly from ovate, with sometimes a little suggestion of a "neck." The stems were slender and of the "Crookneck" type, while the flesh, fairly thick, was of deep orange, detracting nothing from the attractiveness of the squash. The seeds, very few in number, are quite like the "Crookneck" in size and shade of gray.

Q. "*Bay State-Warren*" (21/7). Only one hill produced any sizeable plants and from this three small squashes were secured, two of which are shown at 3, Plate XXI. They were pale cream colored with green around the very large, pea-green navel. The shape, as might be expected from that of the parents, is nearly that of a "cheese," with a long, medium-slender stem (not shown entire

in the engraving). The flesh is a pale orange (lemon), very thick upon the blossom end, and with much green in the region of the navel. Only a small number of seeds was matured.

R. "*Golden Bronze-Delicious*" (23/3). Only two small fruits of this cross were secured, and are shown at 10 and 11, Plate XX. They were of a dull ("dirty") bronze upon a pea-green background, while in shape they resembled the mother, with the flesh very thick and fine-grained, and a rich orange with a thin green layer beneath the skin. The section of the fruit gives many details of the interior.

S. "*Marblehead-Warren*" (24/7). No mature fruits were secured from this cross.

T. "*Dunlap's Marrow-Winter Crookneck*" (25/18). The four small fruits of this cross were all broad oval, and orange, striped with a lighter shade of orange, with the thick flesh of the same color and a broad seed cavity, nearly free from contents, the seeds being very long, and possibly all without vital embryos.

U. "*Warted Hubbard-Dunlap's Marrow*" (26/25). The five fruits secured were all dark orange, with green stripes, and of the "Hubbard" shape. The flesh was thick, pale green near the outside, but orange further toward the center. Seeds were abundant.

V. "*Warted Hubbard-Essex Hybrid*" (26/28). Four oval-flattish fruits were obtained, all of which were pale green, with an inclination to develop cream stripes. The thick, firm flesh was green for a half inch from outside and then light orange inside to the seed cavity, giving a particularly attractive interior, made somewhat irregular by the presence of the navel, that, with one exception, was large and showed a peculiar projection nearly an inch long.

W. "*Canada Crookneck-Hubbard*" (27/1). This hybrid did better than many others upon the poor land and developed its large, dark green fruits quite early in the season. Two specimens are shown at 9 in Plate XXI., where it is seen that the shape is ovate, indistinctly ribbed with a slender stem of the "Crookneck" type. The flesh is uniformly light orange and thin, giving a large cavity, in which but few seeds were developed. The seeds, only a few being plump, are larger than the "Hubbard," and gray and dark-rimmed, like the "Crookneck."

X. "*Faxon-Boston Marrow*" (30/2). The two oval-flat fruits from this cross were small, pea-green and orange-blotched, the green making up the narrow stripes. The flesh was thin and orange colored. There was not enough ground for an expression of an opinion as to the merits of the combination.

Growers' Notes upon Station Winter Squash No. 1.

A hundred and thirty-four packets of the cross of "Hubbard" upon "Boston Marrow" were distributed to testers last spring, but at the time of writing only a few have reported upon their results. The following notes show that some were pleased with the cross: "'Winter Squash' was of excellent quality, medium in size, yellow in color." "Large, strong vines." "Quality is very good and the shape is fine." "Size medium, fair in vigor and productiveness." "Medium size, strong grower, very productive; fifteen nice squashes; quality excellent; cook fine and dry; in my opinion, they are superior to the 'Warted Hubbard' that I raised in the same ground." "Plants have done well; vines strong, vigorous growers." "Healthy and vigorous vines; one vine has eighteen squashes on it, varying in size from tiny ones to about twelve inches around." "Vines are vigorous and healthy." "Squash very productive, vigorous growers and fruit very uniform; from all indications it will become a leading squash for market growers." "The 'Station Winter Squash' has fully equaled our expectations; vine a strong, vigorous grower; I have about twenty squashes, varying in size from twenty inches to twenty-nine inches in circumference; the shape is very uniform, practically the same as the 'Hubbard;' there is quite a variation in color of some."

Notes upon Squash Seeds.

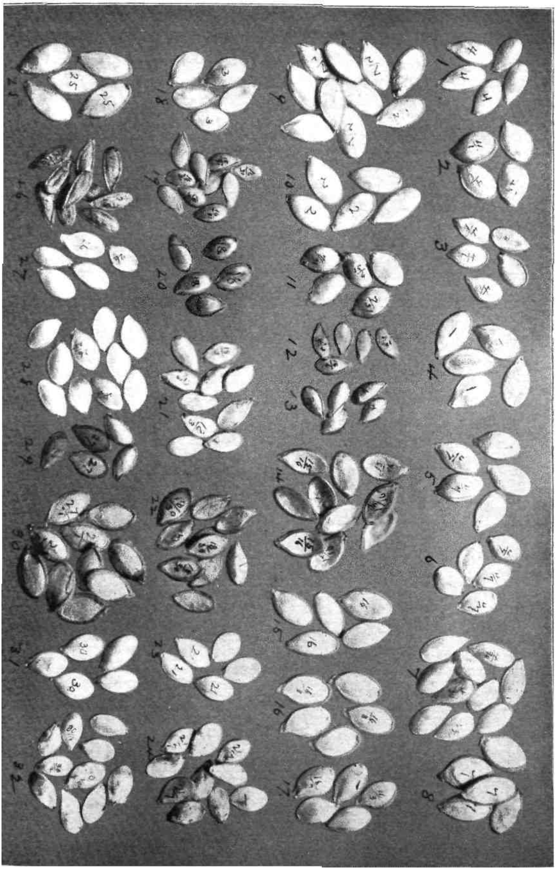
The following are some of the observations made upon the seeds of the vine squashes in connection with those of the crosses that have been secured the present year in their first generation from the blend. Following the order of the numerators (beginning with the lowest) of the fractions expressing the crosses that are represented in Plate XXII., the first cross is "Golden Hubbard" (4) upon "Hubbard" (1). In this cross (4/1), in the first generation after the blend, the seeds in each fruit are of two sizes—a large and small—as shown at 2 and 3, the seeds of the parents being at 1 ("Golden Hubbard") and 2 ("Hubbard"), respectively. It is noted that the seeds of the cross are not of sizes and forms that agree with either parent. At 5 and 6 are shown the seeds from the same fruit—a cross of 4, above named, upon "Warren" (7), and here (4/7), again, there are two sizes, which are not closely adhering to parental types.

In the plate the plan is to show five seeds of each commercial sort that is involved in the crosses represented and ten seeds of each cross, some of the latter being separated into two sets of five, each representing differences where these are apparent. At 7 is shown a set of ten similar seeds that are a cross of the "Golden Hubbard" (4) and "Faxon" (30)—4/30. The seeds of both parents are chalky white, with the one longer and the other broader than the average of the two, as shown in the crossed seeds. The cross at 9 is similarly a combination between two kinds, with no marked difference in their seeds.

The seeds at 11 are of a hybrid between the "Warren" (7) upon the "Japanese" (31)—7/31—and they are quite midway between the two, the "Warren" being large and chalky, while the mother (31) has very small seeds for a vine squash, and of a brown color and a distinct rim. The outer coat in the hybrid seeds is brown and rimmed. In another fruit, from the seeds of the same mother fruit as the last, the seeds (12) are scarcely different from the "Japanese" alongside at 13, and do not show indications of hybridity. The seeds at 14 are shells merely, from a full-grown fruit of "Japanese" (15) upon "Mammoth Chili" (16), and are practically the same as of the mother, plump seeds of which are to their right. That it is safe to infer the size and shape of plump seeds from empty seed coats is demonstrated in nearly every squash fruit, for there are frequently a large fraction without embryos, and they agree with plump ones in external qualities. In the cross of 16/3, "Mammoth Chili" upon "Delicious," there is a marked difference in the seeds of the two parents, and here, again, from the same fruit two sizes and shades of color also are separated, as shown at 16 and 17.

At 19 is a group of ten seeds from a fruit that was grown from seed secured by breeding the "Mammoth Chili" upon the "Japanese," but the seeds do not differ materially from the mother species.

A hybrid between the "Winter Crookneck" (18) and the "Delicious" (18/3) is shown at 21. The seeds (20) are white, like the mother, but much smaller, and are in striking contrast with the "Crookneck," which are more oval, flat, brown and rimmed. The above "Winter Crookneck" upon "Faxon" (18/30) gave seeds brown and thin (22), resembling in these respects those of the male parent as shown at 20, which were very unlike those of the plump, pure white, smooth ones of the mother shown at 31.



At 24 is shown ten seeds of 21/7, that is, "Bay State" upon "Warren," in which the male type of seed is closely adhered to. "Dunlap's Marrow" (25) upon "Winter Crookneck" (25/18) gave only empty seed coats, but these, as shown at 26, were remarkably long, but in other respects closely resembled the mother (18).

The cross between the "Warted Hubbard" (26) upon "Dunlap's Marrow" (26/25) gave handsome, broad, pure white, medium-sized seeds, shown at 28, not agreeing with the characteristics of either parent, but favoring the father.

The large, brown, rimmed seeds shown at 30 resulted from the breeding of the "Canada Crookneck" (27) upon the "Hubbard" (27/1), the seeds of the male parent shown at 29 being much smaller than those of the hybrid, but otherwise similar. The white of the "Hubbard" is entirely lost.

The last cross shown in the plate is of "Faxon" (30) upon "Boston Marrow" (2). Here both parents have chalky-white seeds, but differ in size. From the same fruit two types of seeds could be easily selected, as shown by the two groups of five each at 32.

EXPERIMENTS WITH PEAS.

The following list of commercial varieties of garden peas was grown in limited amount during the present season:

1. "Abundance."
2. "Alaska."
3. "Alpha."
4. "American Wonder."
5. "Black-Eyed Marrowfat."
6. "Champion of England."
7. "Daisy."
8. "Daniel O'Rourke."
9. "Duke of Albany."
10. "Duke of York."
11. "Dwarf Champion."
12. "Everbearing."
13. "Extra Early Exonian."
14. "First of All."
15. "Gradus."
16. "Gray Seed (Mammoth)."
17. "Gregory Surprise."
18. "Heroine."
19. "Horsford's Market Garden."
20. "Melting Sugar."
21. "Nott's Excelsior."
22. "Philadelphia Extra Early."
23. "Premium Gem."
24. "Pride of the Market."
25. "Prince of Wales."
26. "Shropshire Hero."
27. "Sutton's Excelsior."
28. "Sutton's Satisfaction."
29. "Telegraph."
30. "Telephone."
31. "Thomas Laxton."
32. "Thorburn's Extra Early Market
33. "White Marrowfat."
34. "Witham Wonder."
35. "Yorkshire Hero."
36. "Tom Thumb."
37. "Prosperity."
38. "Prolific Early Market."
39. "Ameer."
40. "Admiral."
41. "French Canner."
42. "Dwarf Gray Seeded Sugar."

A set of these seeds in four-ounce bottles has been placed in the Museum for future reference, and some herbarium specimens were secured of the plants grown in the Garden.

Attempts at cross breeding were made between the following kinds, which were grown in pairs of parallel rows, planted early in the season:

"Abundance"–"Admiral."
"Alaska"–"Tom Thumb."
"Alaska"–"Telephone."
"Alaska"–"French Canner."
"American Wonder"–"French Canner."
"Daniel O'Rourke"–"Surprise."
"*Horsford's Market*"–"*First of All*."
"Black-Eyed Marrowfat"–"Prosperity."
"Excelsior"–"Prosperity."
"*First of All*"–"*Telephone*."
"Nott's Excelsior"–"Gradus."
"Thomas Laxton"–"Telephone."
"Ameer" (a few plants alone).

The following suspected crosses were planted June 29th, from which a few seeds were obtained:

1/41—"Abundance/French Canner."
2/41—"Alaska/French Canner."
14/5 —"First of All/Black-Eyed Marrowfat."
14/21—"First of All/Nott's Excelsior."
14/30—"First of All/Telephone."
15/36—"*Gradus/Tom Thumb*."
21/41—"Nott's Excelsior/French Canner."
30/21—"Telephone/Nott's Excelsior."
30/41—"*Telephone/French Canner*."
31/14—"Thomas Laxton/First of All."
36/38—"Tom Thumb/Prolific Early Market."
39/1 —"Ameer/Abundance."
39/36—"Ameer/Tom Thumb."
39/41—"Ameer/French Canner."
40/41—"Admiral/French Canner."
41/4 —"French Canner/American Wonder."
41/15—"French Canner/Gradus."
41/30—"French Canner/Telephone."

The summer season is not, of course, favorable for peas. It was particularly noted that plants having the "French Canner" "blood" represented were unusually strong.

In Plate XXIII. seven crosses of peas are represented, they

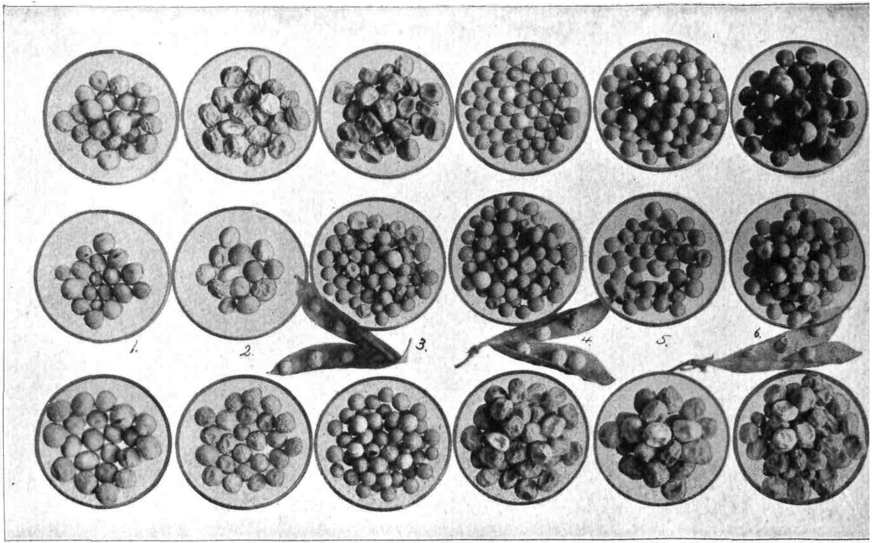


PLATE XXIII

occupying the middle row of watch glasses from left to right. The parents of each are placed with the male above and the female below the cross. For example, the first cross (shown at 1) is that of "First of All" (14) upon the "Black-Eyed Marrowfat" (5). The seeds of the parents are alike in being buff (light tan) colored, but with the latter much larger, less wrinkled, and having a characteristic dark eye, giving the name to the variety. In the cross shown above the latter the seeds are nearly midway in size between the two parents, but they all have the eye-marking of the mother parent.

In the next cross the male parent, "Thomas Laxton" (31) has a quite large and very much wrinkled seed, frequently retaining a greenish color, while the mother is the "First of All" (14), as named in the last cross, and has a medium-sized, often nearly smooth, seed. The seeds of the cross are midway in size of the two parents, and show (2) some seeds fully wrinkled, like the "Laxton," while others are smooth, as in the "First of All."

The "Admiral" (40) upon the "French Canner" (41) combines two varieties representing two widely different types. In the former the seeds are large and extremely wrinkled and of a dull greenish buff color. The "French Canner" has small, spherical, typically smooth seeds that are nearly flesh colored. The differences in the plants of these two sorts are as great as here shown at 3 between the seeds. The cross is near the mother in size of seeds, three-quarters of which are smooth, somewhat larger than the "Canner," but greenish like the "Admiral." It is interesting to note that the wrinkled are larger than the smooth ones. A pod is shown with the five seeds in plate, the second one from the base being larger than the other and dimpled.

At 4 is shown the seeds from a plant that grew from a pea obtained by breeding the "French Canner" (41) upon the "American Wonder" (4). Here, again, the two parents represent the two classes shown in the last cross but with the "Canner" in this case as the mother. The results are nearly the same, for the small. spherical, smooth pea seems to reduce the size to nearly that of its own, the wrinkled ones being somewhat larger as shown in the sample and also by the dimpled seed in the opened pod. The seeds from one of the first generation plants were classified as follows:

Smooth, Gray, Large	62
Smooth, Gray, Small	19
Smooth, Green, Large	10
Smooth, Green, Small	6
Wrinkled, Gray, Large	12
Wrinkled, Gray, Small	10
Wrinkled, Green, Large	6
Wrinkled, Green, Small	2
Total	127

Smooth, 97; wrinkled, 30; large, 90; small, 37; gray, 103; green, 24.

This follows, as closely as might be expected, the numerical results determined by Mendel. Regarding size in the case of peas, it is not always easy to decide to which class a wrinkled seed belongs, and, again, the end peas in a pod frequently vary in size from the others. It remains to be seen what the sizes in the plants from these peas will show as the standard and dwarf types are brought together.

At 5 is shown the seeds of a cross of the "French Canner" (41) upon the "Telephone" (30) and represented by the fraction 41/30. As in the last, the mother variety is one producing a large, green, wrinkled pea, but, unlike the "American Wonder," the "Telephone" is a standard sort. Only a few seeds were secured in the fall crop of the first generation, but they show all the types brought out in the scheme given for the last cross.

The last cross, shown in the plate at 6, is that of a purple flowered plant growing in a mixed crop of peas and oats, "hand worked" upon "Horsford's Market" (19). Of the eighty-four seeds secured, sixty-one were smooth and twenty-three wrinkled, sixty-six gray and eighteen green, sixty-one large and twenty-three small, which is a fairly close approximation in Mendelism. The various types of seeds are shown in the watch glass at 6 with an opened pod below with smooth and wrinkled peas in place.

There are several other crosses, not represented in the plate, showing very striking differences in types of seeds borne upon the same plant; that of "Nott's Excelsior" (21) upon the "French Canner" (41) perhaps will afford a most interesting set of plants in the next generation, as the contrasts of the parents are, of course, very great.

EXPERIMENTS WITH SALSIFY.

Plot 4, Series IV., was sown to salsify June 27th, 1905. In nearly all instances the seed used was obtained by placing paper bags over young heads of the mother plants, and therefore the offspring were bred within the single inflorescence. The numbers used below are those of Prang's Color Chart.

Row 1. The easternmost part of the plot was sown with seed obtained by placing a large bell jar over the plants, thus securing crossing between plants of two types, namely, 95 (light yellow) and 61-y (darker orange, yellow orange). The record for this row is that the plants were much mixed in color.

Row 2. This was sown with seed from a solid row of selected plants of 93 (yellow). This is the color carried by one of the parents of the hybrid, namely, the wild species (*Tragopogon pratensis*). This row of thirty feet was divided into ten sections, each of which was sown with seeds from different close-fertilized heads. No two sections in this row were alike in characteristics of the plants but extremely uniform within the sections from any head. Thus, some sections were with smaller plants than others; some had smooth leaves, others with wavy margins to the foliage. Some sections showed purple in the stems while others were green throughout. In short, there were many indications that all the plants were hybrids. The only characteristic in which there was constancy was the color of the flowers. It was a solid yellow row, and, with a single exception, all the ten sections showed the same shade; the second section of over four feet had a lighter shade of yellow—No. 94 of the Prang Chart.

Row 3. This was made up of five sections, all quite different in color value, but the whole row showed a very much mixed display of flowers.

Row 4. This consisted entirely of 41-y (darker orange, red orange), and proved to be a mixed lot when in bloom.

Row 5. This was sown with seed of No. 31 (darker red orange), and while the four sections differed from each other in many things, the blooms were all true to the type of the mother plants.

Row 6. This had 31y (darker red orange) for one portion and 21 (dark red, red orange) for the other. The former had a few yellow (93) blooming plants among these, otherwise true to seed

sown. All of the row having No. 21 was solid of the kind of the parent.

Row 7. While this row was sown with seeds from six heads of the same type—21-y (dark red, red orange)—no two sections were alike, and in three the blooms were mixed. The finest plants were in the second section, from which seed from bagged heads was saved. The general type here was of the garden species, with no sign of purple in the stem or leaf, but differing greatly in the color and size of the flowers. It was a very distinct hybrid that is full of promise.

Row 8. This was made up of four sections, all sown with seeds from heads with color, dark red (12). With the exception of one plant, the parent color was present in all the offspring in the first two sections. In the third section there were no two plants alike, suggesting that in this instance there was an error, and the head used had not been covered during the season of bloom.

Row 9. This was sown with No. 242 (dark red, red violet), and in the first section there was a large percentage of the same type, save with the yellow eye (242-y). The same was true of the third section, where 60 per cent. were 242-y. In the last two sections the plants were all solid 242.

Row 10. This was sown with No. 233 (red violet), and made a remarkably strong line of plants. In the third section, while nearly all were true to parent, a few had a yellow "eye" (233-y), two were with nearly white flowers, and one a most delicate shade of peach. All the plants in this row had but few (15 to 20) ray flowers with the long tips of the involucre extending beyond the rays, giving a striking "starry" appearance. The next section of twelve feet was unusually fine, approaching the garden species, having leaves very glaucus, no purple in stems or foliage, with the flowers solid 233 and coiled inward in a most peculiar manner.

Rows 11, 12 and 13 were made up of several shades, all of which were quite close to the parent type.

Row 14. This was sown with 234 (light red violet), and consisted of seven sections; they all came true to parent type.

Row 15. This was sown with seed gathered from plants of No. 95 (yellow), confined under mosquito netting during the blooming period. The plants were all true to parent color (95), but were evidently a combination in many respects of the two species involved in the hybrid.

Row 16. This was sown similar to the above with seeds obtained from plants of No. 234 (light red violet), confined under mosquito netting. Here, again, the blooms all came true to the parent color (234), while in other respects the plants were a true hybrid that approached the garden species.

Row 17. This was sown with seeds obtained in an attempt to cross the wild upon the garden species. The flowers were all yellow and not of the colors that had been obtained in hybrids of previous years.

Row 18. This was sown with seeds obtained in an attempt to cross the Black (Scorzonera) upon the Wild Salsify. All were with yellow blooms of the wild type.

Row 19. This was sown with seeds obtained in an attempt to cross the wild upon the black species. No hybrids were in evidence.

Row 20. This was sown with seeds obtained in an attempt to cross the black upon the garden species. All were straight garden salsify plants.

Several rows of hybrids of the wild and garden species were grown from seeds perfected in the open and the number of types and shades were as published in tabular form for last year, pages 502–506.

Salsify in the Old Plot.

Hybrid salsify has been left to take care of itself for six years upon a half plot of the Gardens.

Upon May 25th, the number of plants with yellow (93) flowers was 345 to 125 of all other colors. Upon the following morning, the yellow flowered plants counted were 444, and those of all other colors 182. Of the latter only 12 were of the Garden parent, namely, light violet, red violet (224), while 146 were dark red, red orange (21), of which 121 were with a yellow center ("eye") to the head. The twenty-four remaining plants represented fourteen shades of color.

It is seen that the area is rapidly running toward the yellow (93) color of the wild parent, while the color (224) of the cultivated species is poorly represented. The large number of the shade (21) with a yellow "eye" is noted.

The study of the salsify hybrids has illustrated the remarkable variation in color caused by a union of two species widely different but very constant in the color of their respective blossoms. At the present stage of the experiment it seems quite probable that any shade that has come to view may be fixed by close fertilization (that is, within the head), and it is inferred that many other minor qualities may be secured in like manner.

The experiment was beset with unusual difficulties in the weediness of the plants, their wide dispersion by the winds and the difficulty of protecting any uncovered seed from sparrows and other birds. It was discontinued, not from lack of interest, but because it was becoming something of a nuisance.

NOTES UPON UDO.

The twenty-five Udo plants came safely through the winter, with only a little cover of coarse manure, and made a vigorous growth. Unfortunately the cover was removed too soon and the blanching of the stems was confined to only a few plants, over which barrels were placed.

Cuttings were made upon April 20th and the stalks, prepared like asparagus, proved to be of superior quality. In flavor, the Udo is somewhat like that of a parsnip, but of a more delicate character, with possibly a little of a balsamic taste. As the aralias are closely related to the caraway and celery, the flavor is one that some may not like, while others will be partial to it.

Upon May 5th, a quantity—sufficient for twenty persons, were the material asparagus—was cut and a few shoots were photographed. Some of the stems, taken from under the barrel, were over two feet long, and in some instances an inch and a half in diameter at the base, while the leaf stalks were a half that size and bleached and very tender. Such leaf stalks quite resemble celery in appearance, but are more cylindrical and longer, equally tender and particularly toothsome when eaten raw.

The lower parts of the stems, as shown in Plate XXIV., may be cut six or more inches long, to be bunched, as is the practice with asparagus. Stems of Udo have whatever there is of woody tissue near the outside—the stem being of the exogenous type—while the center is as tender as the flesh of a ripe pear, which it resembles when freshly cut. The Udo stems hold their shape

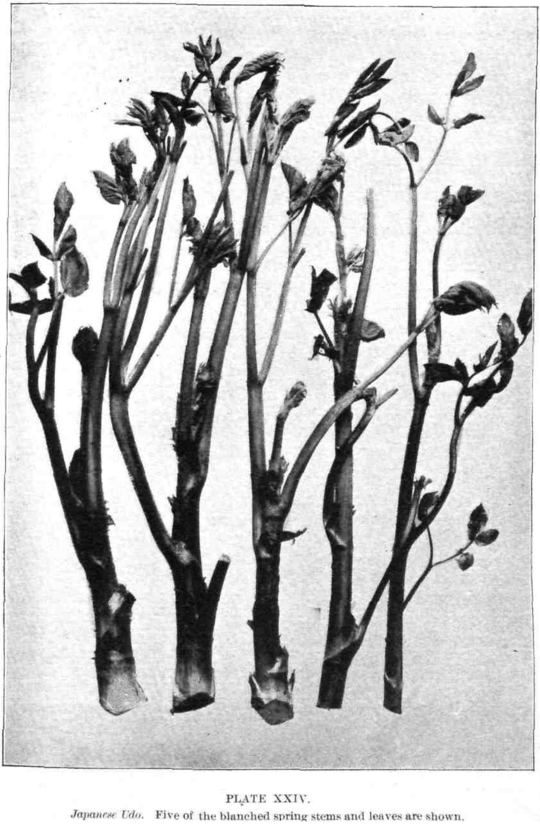


PLATE XXIV.

Japanese Udo. Five of the blanched spring stems and leaves are shown.

well in cooking because of the softest part being within, and may be served the same as asparagus, but without the woody base, so objectionable with the latter vegetable.

The midsummer growth of the Udo was not satisfactory, the plants being infested with a blight that caused the leaves to turn brown, and before the season was through the whole group of plants was nearly leafless. Flowers failed to form, with few exceptions, and no seed was gathered. It is likely that spraying will check this disease, but it was purposely withheld. There is fear that the Udo may have a serious enemy in the blight in question, the exact nature of which is under consideration.

CHINESE VEGETABLES.

Eighteen packets of Chinese vegetable seeds (Numbers 17858-17953) were received last spring through the courtesy of the United States Department of Agriculture, and some of these have shown qualities deserving special mention. The U. S. D. A. 17867 is a cabbage-like plant, particularly as to the smooth, waxy blade of the leaf, the midrib of which is very large, nearly white and resembles that of the Swiss chard. Professor Bailey* figures this under the name of Pak-Choi. Six specimens of differing ages are shown in the upper half of Plate XXV. The plant at 1 has been cut lengthwise through the center to show the pure white interior, made up of the younger leaves with their coral-like stalks and midribs. It is these pure white-leaf stalks and the smaller leaves with them, making up an interior similar to a "head" of lettuce, that are used for the table and may be prepared in the same manner as cabbage or cauliflower and make a very acceptable substitute for either. It may be used in the raw condition, similar to celery, in the making of salads. At 2 a smaller plant is seen tied with a tape ready for the market, and strings have been placed around the much-spreading leaves of smaller plants at 3, 4 and 5 to draw them together for the more complete bleaching of the interior during the latter portion of the plant's stay in the ground.

A few of the plants sent up flower stalks, and, by midsummer, had matured a crop of seeds, the main portion of which was har-

* "Some Recent Chinese Vegetables." L. H. Bailey. Bulletin No. 67, New York (Cornell) Experiment Station, June, 1894.

vested, but, from those that became scattered upon the ground around the parent plants, new seedlings grew that throve during the autumn months and produced plants for the table. It was from this second crop from self-sown seeds that the specimens were gathered for the picture shown in the upper row of Plate XXV. Similar plants left longer in the ground became of large size. The Pak-Choi is particularly well adapted for an autumn crop in our climate.

The second vegetable worthy of mention came from U. S. D. A. 17865, which Professor Bailey figures in the above-mentioned bulletin under the name of Pe-Tsai, concerning which he writes that it "is properly an annual, which has the habit of a giant lettuce * * * and needs a moist and cool soil for its best development." In the present test the seeds of this vegetable (as also Pak-Choi) were sown in the greenhouse and the seedlings transplanted, as in the case of ordinary cabbage, to the open, when they came forward rapidly and produced plants with many large, lettuce-like leaves having broad white midribs and altogether weighing three or more pounds. Small second-crop plants from the self-sowing of seeds from matured plants in midsummer are shown in the lower half of Plate XXV. As in the case of Pak-Choi, the plants are with wide-spreading foliage and it is well to tie the leaves together for the purpose of more thorough blanching, as the plants approach the time for gathering.

The differences between the two cabbage-like vegetables are very apparent when grown in the field, but, as arranged for the combination picture, their likeness is great. It will be observed, however, that the lower row shows leaves that have the blade reaching to the base and the upper ends are irregular like lettuce, while, in the upper row, the stalk extends several inches below the blade, the latter being quite thick and smooth. In short, the Pak-Choi (upper row) is quite like a cabbage in color and texture, while the Pe-Tsai might well be called a giant lettuce.

Both have been grown side by side and the volunteer second crop occupied, without order, the same land, and in practical outcome there is very little difference, and, by an occasional plant of the fruit crop producing seed, these vegetables can be easily propagated, and, thriving in the cool months of late autumn, may deserve a place in the home garden as well as the field of the trucker.

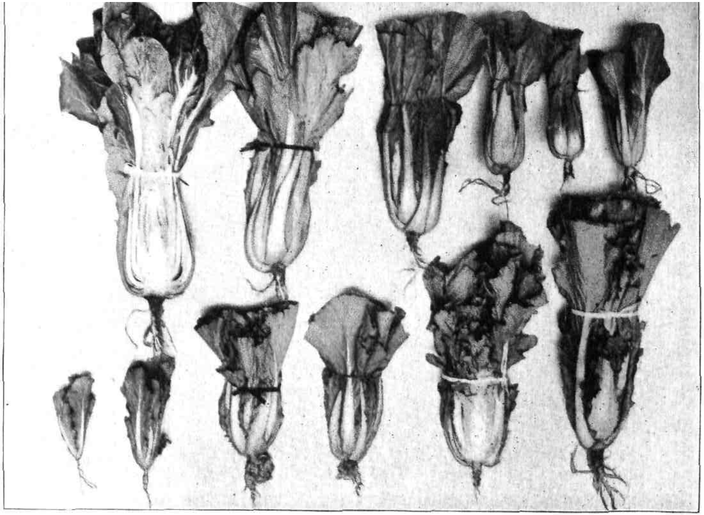


PLATE XXV.

Chinese Vegetables. The "Pak-Choi" is shown at different ages in the upper row, and "Pe-Tsai" is similarly displayed in the lower part of the plate.

EXPERIMENTS WITH OKRA ("GUMBO").

The okra as a vegetable is, perhaps, less known in the State than it deserves. Frequently visitors to the Gardens have there seen the growing okra plants for the first time, while others quickly recognized them as special favorites. The latter were usually from the South, where this garden crop, aften called gumbo, is much more commonly grown than with us. Okra is the subject of a bulletin* by Mr. Beattie, who states that it has been in use in Europe for centuries, and is of tropical origin.

The okra (*Hibiscus esculentus*) is a member of the mallow family, and shows close kinship to cotton, various abutilons, marshmallows and similar giant-flowered plants of the hollyhock type. It is an annual with straight, large, stiff stems, bearing large "maple-shaped" leaves and the funnel-shaped, lemon-colored flowers, followed by pods that sometimes attain a length of nearly a foot. These pods are the portion used, and need to be gathered only two days or so after the flower has passed, when they abound in a mucilaginous substance that imparts a pleasant consistency as well as flavor to soups.

The crop is easily grown, and as the ordinary sorts attain a height of three or more feet, and bear large, broad leaves, the plants need more space than onions or bush beans, and do their best when at least two feet apart each way. There are dwarf sorts that may be given less space.

Through the kindness of Mr. Beattie, seeds of a number of types of okra plants were obtained, and although some sorts did not germinate, by supplementing the list from the commercial seedsmen, several varieties were grown.

From the okra plants grown last year selection was made of a standard sort with long, slender pods, and of a dwarf form of plant with shorter, thicker pods. Seed from each was planted this season and designated as "Home" (standard) and "Home" (dwarf), respectively; the former produced tall plants bearing long, thin pods, while the latter twenty-one plants all bred true to type, that is, were low plants with short, thick pods, and one plant bore slender pods.

* "Okra: Its Culture and Uses." W. R. Beattie. Farmer's Bulletin No. 232, U. S. D. A., 1905.

"Kleckley's Favorite" produced plants of medium height and white pods of medium length.

"New Lady Finger" gave dwarf plants with very long, curved, slender pods.

"Dwarf Prolific," represented by only one plant, was medium in height with short pods, and dark green in color.

"Dwarf 3291," with but one exception, conformed to the dwarf type of plant, and produced pods of medium length, dark green before ripening.

The above varieties gave three general types of pods: (1) long slender; (2) medium slender, and (3) short thick, which varied in color from a dark green to white (or cream).

From Mr. Beattie's bulletin the following classification of the okras is developed:

Plants, Standard—
- Long pod
- Short pod.

Plants, Dwarf—
- Plants dark green
  - Long pod
  - Short pod
- Plants pale green
  - Green pod
  - White pod.

The standard type has plants from four to eight feet tall, while the dwarfs are usually less than three feet high. The latter are divided upon the color of the foliage, one group having the ordinary green foliage of the standards, while the other has a lighter prevailing color in the leaves. A pod is long when exceeding seven, and short when less than five inches. In the last-named group with pale green plants, the pods are slender, and the name of "Lady Finger" is given to them; they are divided into those with green and others with white pods.

The varieties grown in the Gardens furnished representatives of all the six groups in the above classification, excepting the last, which is a dwarf, with pale green foliage and a slender white pod. One of these, the "White Louisiana," is recommended as among the best for cultivation, the leading one for general use being the dwarf green, long pod.

EXPERIMENTS WITH ONIONS.

In the spring of 1904 onion sets of the "White Globe," "Yellow Globe" and "Red Globe" were obtained from a seedsman making a specialty of growing pure strains of this vegetable and were planted in double rows so that the flowers of two varieties could be easily cross-pollinated. "Suspect" seed was obtained as follows: "White" upon "Yellow," "Red" upon "White" and "Red" upon "Yellow." From this "suspected" seed bulbs were obtained in 1905, and these have been grown for seed the present season. The flower "balls" were covered with large paper bags before blooms appeared and removed after the seed had set. This seed, resulting from fertilization within the plant, may be the starting of new types of onions.

From commercial onion sets of "Michigan Red" and "Southport Yellow" "suspect" seed was obtained as follows: "Red" upon "Yellow" and "Yellow" upon "Red."

These last-named bulbs were grown alongside of the set previously mentioned, but they were much smaller in flower stalk and cluster than those of the home-grown bulbs.

Seed onions were obtained for further breeding of the "Michigan Yellow Globe," "Southport Red Globe" and "White Globe." While the soil is not of the best for onions, there are certain plots in the Gardens that will permit of the breeding of this vegetable.

EXPERIMENTS WITH ORNAMENTAL PLANTS.

A small portion of the Gardens was devoted to ornamental plants, with which some attempts were made in breeding.

Antirrhinum (Snap-Dragon).—The "Dwarf White" and Standard Red" were grown with the object of crossing the two. The dwarf form with its compact growth and showy flowers makes a desirable bedding plant and continues blooming until late fall.

Dolichos.—Four varieties of this flowering bean were grown, "Giant Crimson," "Dwarf White," "Purple Soudan" and "Standard White." "Purple Soudan" differs from the "Giant Crimson" in its dark stem and foliage, darker flowers and purple pods; the "Giant Crimson" comes into bloom earlier. For early bloom

the "Dwarf White" is desirable, but the "Standard White" excels in its profusion of white flowers, borne ten feet from the ground and lasting for a long time. Pods white.

Hibiscus (Golden Bowl).—Plants from four to five feet tall, bearing large, showy flowers resembling the okra. "Suspects" have been obtained between it and the okra.

Ipomoea (Morning Glories).—At the "Camp" about twenty varieties were grown. They made a large and rapid growth of from ten to fifteen feet and their profusion of rich bloom was arrested only by frost. Forty-one crosses were obtained among them (including reciprocals and some duplicates). One plant showed a decided tendency to form what are known as "double flowers."

The normal plants from the same packet of seed had nearly white flowers that were under the average size for the species and the bell-shaped corolla did not flare, and therefore is somewhat near the tubular type of blossom. In addition to this, there were five long red splashes equidistant upon the corolla, one upon the upper portion of the midrib of each petaloid leaf composing the corolla. These color marks are of interest in the study of the doubled blossom. In the calyx the chief change from the normal in the flowers in question was the abbreviated lobes which were half the usual length. The many parts to the corolla caused the buds to be very plump and the petals showed their crumpled edges for some days before the full bloom appeared.

Upon looking down into the flower the style and fine stamens were seen to be normal in all visible respects. The five innermost parts of the corolla were broader than any other, long, spatulate and blotched with red near the geographical middle of the broadened upper end and arranged equidistant like the points of a star. These, it seems probable, were the parts that correspond to the middle of each of the five equal parts making up the ordinary corolla.

The blotched petals may be easily separated from the others by a downward pull, but, along with each, a cluster of adhering fine petaloid white parts is removed. The stamens alternated with the blotched petals as they do with the lobes of the normal corolla.

It is evident that the fine, fluffy, chrysanthemum-like appearance of the doubled morning glory was caused by a supplemental

growth from the outside of the ordinary corolla, there arising from near the base of the tube a large number—fifty or more—slender, often hair-like petaloid structures, which, being enlarged and more or less coiled at the upper end, gave a very unusual not to say surprising array of blossoms that were so evanescent that only with much difficulty could the delicate parts be arranged in the press. Their capacity in breeding is problematical.

Convolvulus minor.—This is a dwarf Morning Glory with large, handsome flowers borne in profusion. Attempts have been made to breed it with the twining species of the genus.

"Jerusalem Cherry."—Plants of dark green foliage, small white flowers and cherry-like fruit, turning red at maturity, making the plant quite ornamental. A "suspect" was obtained between it and the "Garden Huckleberry."

Lathyrus.—Started early in the greenhouse and came into bloom late, after the Sweet Peas had ceased blooming. It is desired to cross this with the Sweet Pea with the object of obtaining a scented Perennial Pea.

Lavatera.—A promising cut flower with flowers resembling the hollyhock, but much smaller. Attempts are being made to cross this with the mallow pest of the garden and field; also, with the Malope.

Malope.—Plant resembles Lavatera; flowers also, in form, but much finer in coloring, being of a rich red.

Poppy.—Single Red, Double Red, Shirley and Mexican varieties were grown, and attempts made to cross them.

Petunia.—Dwarf Star fine for bedding, but does not always come true, many of the flowers being purple. "Single Fringed" seems to be an excellent variety. Flowers changed their coloring through the season, being richer and darker in the autumn. "Giant Crimson" gave some plants with flowers of the "Standard Crimson." "Giant Quadricolor" is a very showy flower, with plants less hardy than the other varieties. The two leading species have been grown side by side the present season, and they seem to hybridize with ease. Several capsules of seed, through "hand-working," have been secured. The several plants of the commercial sorts furnished a subject for the study of variability, and a set of the different types of stem and foliage was secured for the Herbarium. One plant, in particular, might be considered a

mutant, so widely different was it from the others. The plant in question was wide-spreading and low, the leaves of which were not half as large as the average, and arranged without the usual length of internodes. These characteristics gave the plant a striking appearance and, in addition, while the plants upon all sides bloomed freely, this one did not produce a single flower bud. For the purpose of ordinary petunias—that is, garden display of various shades—this plant was, of course, a failure.

Sweet Peas.—With the hot days of summer all the varieties died down. The "Cupid" dropped its buds just before blooming. All attempts at crossing were unsuccessful.

TEST OF RUST-RESISTING CANTALOUPES.

Through the kindness of Professor P. K. Blinn, of the Colorado Experiment Station, a quantity of a Rust-Resisting Cantaloupe* was received by this department and distributed to growers who make a specialty of this crop. The demand for this seed was so great that a request was made for a supplemental package, but as the supply of the seed of the desired kind was exhausted, Professor Blinn kindly forwarded a generous supply of the "Pollock Strain of the Rocky Ford Cantaloupe," and this was freely distributed in liberal packets.

Twenty-four New Jersey citron growers received both the "Rust-Resisting" and "Pollock Strain," and seventeen additional truckers had only the latter, making in all forty-one persons who made the test.

It may be well to include here a copy of the letter of transmissal of both the "Rust-Resisting" and the "Pollock Strain" of Cantaloupes:

FEBRUARY 8th, 1906.

DEAR SIR—The Experiment Station has just received some seed of the "Rocky Ford" Cantaloupe from the Colorado Experiment Station. It is claimed that this seed is from plants that are strongly resistant to disease, and I am desirous of testing it in fields along with cantaloupes of the ordinary sorts, to determine whether this strain is of special value for "citron" growers of this State.

---

* "A Rust-Resisting Cantaloupe." P. K. Blinn. Bulletin No. 104, Colorado Experiment Station, November, 1905.

The seed in question is from plants that were selected some years ago because of their fine health when growing in the midst of other muskmelon plants that suffered badly from disease, and the offspring bred within themselves seem to have the resistant power well fixed under the conditions obtaining in Colorado.

Please indicate upon addressed postal card whether you can give the seeds a thorough test. Any names of large melon growers who have suffered from blights, etc., you may be pleased to send me will aid in extending the trial.

Yours very truly,

——— ———.

FEBRUARY 16th, 1906.

DEAR SIR—In response to your generous request to make a melon (citron) test as suggested in my letter of the 8th inst., it gives me pleasure to send you herewith a packet of the "Rust-Resisting Cantaloupe" from the Colorado Experiment Station.

It is desired that these seeds be planted and the plants therefrom treated in every way the same as those of the general stock that you grow. It would be well to plant the seeds so that the vines from them may be surrounded by the other cantaloupes.

Furthermore, it is desired that observations be made upon the plants from time to time, and particularly as to the amount of disease they show as compared with the plants surrounding them. Should the vines in question prove superior, it scarcely needs be written that seed should be saved from the best mature fruits.

Yours very truly,

——— ———.

MARCH 9th, 1906.

DEAR SIR—Since the small packet of "Rust-Resisting Cantaloupe" seed was sent to you, I have received from the Colorado Experiment Station a more liberal supply of the "Pollock Strain of Rocky Ford Cantaloupe," and it gives me pleasure to enclose a packet of the same.

This last strain is of very high quality, as grown in Colorado, and it may show much merit in New Jersey. It is not claimed to be as rust-resisting as the first-named, but is less susceptible than the ordinary sorts to disease.

Please find a place for both samples in your melon fields, and be upon the watch for points of superiority.

Any report upon your tests will be gladly received by the Experiment Station.

Yours very truly,

———

From the reports submitted the following remarks are extracted: "As yet we note no difference in the 'Rust-Resisting Cantaloupe' from the other varieties." "The 'Rust-Resisting' strain lived for ten days after our 'Jenny Lind' died and then succumbed to the excessive rains; the 'Pollock' strain also lived well; we think that these strains of blight-resisting cantaloupes promise much." "I would say the seed you sent me shows as little blight as any of eight different kinds of seed I planted." "I planted one row in the middle of the patch and I cannot find one hill but that shows some rust or blight, neither do I find one hill with a crop of citron on it; four citron seems to be the highest number on a hill; I would not think them worth much as a cropper." "In regard to 'Rocky Fords,' crop was medium, cantaloupes were quite uniform in size, well netted and good flavor, very few culls; vines looked well all the season but are about dead now; cantaloupes began ripening about August 10th and continued to September 10th, but were not picked as often as they should have been." "The 'Rust-Resisting' seeds are doing fine and show no signs of rust." "The 'Pollock Strain of Rocky Ford' have made a very rapid growth and first fruit will be ripe in about three days. There is only one hill of rust showing, which I think is very good, as they have never been sprayed; they have set more fruit than the other vines and especially earlier fruit." "None of the 'Rocky Ford' melon seed did well in our soil; possibly the season was not suitable." "There were some right good melons on the 'Pollock Strain of Rocky Ford Cantaloupe' vines, but, on the whole, I did not save any seed, as they were not netted enough or as good flavor to be good sellers." "'Rust-Resisting Cantaloupe' healthy, no sign of rust or blight; fruit beginning to set; seed planted about the 1st of June." "No appearance of rust or blight as yet in 'Pollock Strain of Rocky Ford' melons; they are making fine growth, fruit beginning to set; am watching the test with much interest, for several years past blight has destroyed vines soon after fruit began to ripen." "I have gathered a crop of 'Rocky Ford' cantaloupes of fair quality, the vines commenced to blight before we had a ripe melon; the plants did not succumb entirely until most of the crop was harvested; the fruit was of good size and shape." "The condition of the 'Rust-Resisting' cantaloupe is very favorable at this date; no sign of blight has yet appeared with any of the varieties." "The 'Pollock Strain' is producing more sets for fruit

than any of my other melons." "The 'Pollock Strain' cantaloupes are all blighted and not any fruit matured except where I sprayed them, there they have not shed a leaf where some other varieties, sprayed the same, have blighted considerably." "The 'Rust-Resisting Cantaloupes' that I am testing are in a healthy condition; no apparent improvement over the ordinary 'Rocky Fords.'" "The 'Pollock Strain' melons are in a healthy condition; no noticeable improvement over ordinary variety grown side by side." "The cantaloupe season is over and I find the 'Pollock Strain' no improvement over the kind I already have; however, the 'Rust-Resisting,' while a trifle later, are an improvement; vines stay green longer; I have saved all the seed to plant another year." "The vines seem to do better—the 'Rocky Ford'—and I wish to give a more satisfactory trial next season." "The 'Pollock Strain' do not show any signs of blight as yet, but the heavy rains washed the early blossoms off; they are looking fine now." "The vines of all citrons are looking well and at present can see no difference in our regular citron, 'Rust-Resisting' and 'Pollock Strain.'" "Rust first appeared on 'Pollock Strain' on August 10th; could see no difference the whole season between this strain and our regular cantaloupe." "On August 10th, when rust was first noticed on our regular cantaloupes, the 'Rust-Resisting' had two or three spotted, on August 24th not more than 10 per cent. as compared with 25 per cent. on the others, on August 31st about 20 per cent. and to-day (September 7th) about 25 per cent. to 30 per cent., while the others are practically gone." "The 'Rust-Resisting' cover an average of thirty square feet, show no signs of rust yet, though we have had a great deal of damp weather; they are rank color and hardy; the 'Pollock Strain' show some rust and are not a very good color." "The 'Rust-Resisting' cantaloupe were of an excellent flavor, vines keeping green long after citrons were done picking, large yield; the 'Pollock Strain' were an utter failure." "Regret to report that the wet weather and lack of sunshine completely destroyed my dozen hills of the 'Pollock Strain;' they only reached four inches in height; the 'Rust-Resisting' melons suffered the same fate though they were far in advance, when they simply rotted off at the stems at the surface of the ground." "Am testing the 'Pollock Strain' alongside several other varieties and can see no perceptible difference as yet." "I could see no material difference in the appearance of the vines of the 'Rust-Resisting'

and the 'Pollock Strain' until about the middle of August, whe the leaves of the latter turned brown and the fruit ripened nearl all at once. The 'Rust-Resisting' leaves were quite green and ar not quite dead yet (September 10th); I picked the last of th fruit to-day; it is a poor quality and does not yield as well as th 'Pollock Strain,' which was of fine quality, but seemed to ripe prematurely; 'Emerald Gem,' planted alongside, about the sam as the 'Pollock Strain.'" "The rabbits got the most of ours a fast as they came up, but what is standing does not seem to b blighting as much as our own variety; they do not seem to be se any heavier than our own; as yet we have not picked any, but th vines look strong and healthy; the 'Pollock Strain' are clear o rust and have a fine crop, doing better than my own seed in sam soil." "Would say that some of the vines of the 'Pollock Strair did not have any melons on them, while those that did were fai but not extra good; the vines have kept nice and green as also ha the citron; the vines are still alive while we have finished pickin them."

Rainfall of the Growing Season for Past Seventeen Years.

	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	1904.	1905.	1906.	Average.
....	5.32	2.65	2.19	2.49	5 21	3.09	4.88	1.35	3 79	3.74	1.73	2.29	6.31	3.62	3.97	3 43	2.88	3.64	3.46
....	4.09	4 24	2.97	5.04	4.07	7.72	2.85	3.21	5.68	7.00	1.92	4.71	5.60	2.04	0 59	2.60	1.71	4.21	3.90
....	3.73	3.59	2.92	3.85	2 95	2.28	3 24	5.46	3.38	2.10	2.50	3.08	1.57	6.57	7.68	3.13	3.43	4.48	3.67
....	10.19	5.62	5.30	4.03	2.72	1.66	4.26	5.50	11 42	4.96	5.75	4.74	5.87	4.78	5.51	4.87	4.06	5.58	5.39
t........................	5.18	4.90	5.32	3.63	6.52	2.58	1.83	4 39	5.36	4.36	2.68	9.43.	3.91	6.95	6.95	6.62	5.72	5.95	4.22
nber........................	8.36	4.75	2.46	1.81	3.30	7.46	1.07	4.37	1.65	2.00	5.88	2.86	3.38	5.65	3.34	4.79	5.23	2.19	3 91
Totals	36.87	25.75	21.16	20.85	24.67	24.79	18.83	21 72	30.31	25.16	22.14	20.36	32.16	26.57	28.01	25.43	23.03	26.05	24.55
Average.	6.14	4.30	3.53	3.47	4.11	4.13	3.14	3.62	5.05	4.19	3.69	3.39	5.36	4.43	4 67	4.27	3.84	4 36	4.09
Rank in Wetness....	1	7	15	16	11	10	18	14	3	9	13	17	2	5	4	8	12	6	......
Rank in Dryness.....	8	12	4	3	8	9	1	5	16	10	6	2	17	14	15	11	7	13	......

Temperature of the Growing Season for Past Seventeen Years.

	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	1904.	1905.	1906.	Average.
.	51.2	50.4	52.0	49.3	49.2	50.3	49.1	52.4	5.04	47.8	49.9	50.8	48.3	50.2	50.9	46.7	49.9	51.2	49.4
y..........	62.3	60.7	59.5	60.1	59.4	61.4	60.9	65.3	60.6	58.5	61.1	60.9	58.6	60.3	62.7	62.8	61.4	61.0	60.9
ne..........	69.9	70.7	69.7	72.4	69.7	70.6	71.7	68.1	66.1	70.1	72.3	70.4	70.0	67.5	64.0	68.6	68.3	70.4	69.3
ly..........	73.4	72.5	70.1	74.3	73.9	75.7	70.9	75.0	74.1	75.3	74.7	75.9	77.3	73.0	73.3	72.3	74.4	72.8	73.8
igust..........	69.6	71.5	72.8	73.4	72.8	70.9	74.2	73.6	71.0	74.8	72.3	76.3	73.8	70.1	68.4	70.8	71.1	74.6	72.2
ptember..........	64.8	64.4	68.7	64.2	62.7	68.3	69.7	65.1	65.5	68.6	64.4	69.9	66.8	64.6	65.0	64.8	65.4	68.9	66.1
Average..........	65.2	65.0	65.4	65.6	64.6	66.2	66.1	66.6	64.6	65.9	65.8	67.4	65.8	64.3	64.0	64.3	65.1	66.5	65.3
Rank in Warmth	12	13	10	9	14	4	5	2	15	6	7	1	8	16	18	17	11	3	......
Rank in Coldness	7	6	9	10	5	15	14	17	4	13	12	18	11	3	1	2	8	16	......

Sunshine of the Growing Season for the Past Seventeen Years in Percentage of Clear-Partly-Cloudy Days.

	1889. Per cent.	1890. Per cent.	1891. Per cent.	1892. Per cent.	1893. Per cent.	1894. Per cent.	1895. Per cent.	1896. Per cent.	1897. Per cent.	1898. Per cent.	1899. Per cent.	1900. Per cent.	1901. Per cent.	1902. Per cent.	1903. Per cent.	1904. Per cent.	1905. Per cent.	1906. Per cent.	Average. Per cent.
pril	53	76	80	53	60	70	60	76	83	62	87	77	50	70	66	70	77	83	66.7
ay	65	66	64	71	69	65	78	71	78	52	77	75	58	84	84	84	74	77	67.3
ıne	66	80	76	76	70	83	73	73	80	87	84	80	87	83	53	77	77	73	72.9
ıly	58	76	69	84	87	84	78	74	68	74	77	87	71	71	84	74	81	81	72 6
ugust	74	77	61	78	81	80	90	87	84	77	71	84	71	90	65	81	74	68	74.0
ptember	53	66	83	87	73	66	90	70	87	83	80	80	80	60	83	80	76	80	72.6
Average	61.5	73.5	72.2	78.2	73.3	74.7	78.2	75.2	80.0	72.7	79.3	78.9	69 5	76.3	72.7	77.7	76 5	77.0	71.0
Rank in Brightness	18	11	15	4	12	10	5	9	1	13	2	3	17	8	14	6	7	16	......
Rank in Darkness	1	8	4	15	7	9	14	10	18	6	17	16	2	11	5	13	12	3	......

WEATHER NOTES OF THE GROWING SEASON.

Herewith (page 511) is given a table of the New Jersey rainfall for the growing season—April to September, inclusive—for the past seventeen years. It is seen that for 1906 the precipitation has been an inch and a half above the average, and this excess was distributed over all the months, excepting September, which was quite dry, and the preceding month, rainy. The season, as regards moisture, was satisfactory, and upon the Gardens there was no time when irrigation was urgent.

The table upon page 512 shows that the temperature was above the average for all the months, excepting July. A glance at the "rank in warmth" line will show that the present season was third in high temperature, being exceeded only by 1896 and 1900. Combining the facts above stated, the season in question was hot and fairly moist.

The third table, upon page 513, shows that the growing season of 1906 was a dark one, being exceeded in cloudiness only by 1901 and 1889. In brief, the last season was moist, dark and hot.

There has been fully an average amount of plant diseases during the year. Early in the season there were many complaints of blight upon all orchard trees, that of the apple being especially in evidence. Among truck crops, the lima beans were perhaps the most to suffer from a mildew, appearing in August, and being particularly destructive in some localities.

The comparatively dry September proved very helpful to the potato growers, whose crop was prevented thereby from serious decay.

REPORT OF THE ENTOMOLOGIST.

REPORT OF THE ENTOMOLOGIST.

BY JOHN B. SMITH, SC.D.

GENERAL REVIEW.

The season of 1906 was characterized in its entirety by an excess of wet weather, which, while it favored the development of a few species, was on the whole adverse to insect life, and favored the development and spread of epidemic disease, such as that which was noted amongst grasshoppers. There was a steady increase in some species and, on the other hand, a distinct decrease in others that were troublesome in preceding seasons. It was in the main a favorable one for the farmer and fruit grower from the entomological standpoint, although severe individual losses were recorded.

Scale Insects.

Scale insects have been troublesome throughout the State, as usual, and on as great a variety of plants, and attention to them has occupied a considerable portion of the time of the office force.

The *San José* or pernicious scale still leads all others in importance, and has required more attention than all the remaining species taken together. The correspondence concerning it was heavy, and more than two-thirds of the time of the assistant to the State Entomologist has been devoted to inspection work in orchards and nurseries alone. Little remains to be learnt of the life history and habits of the insect, but we are far from understanding all the factors connected with its successful treatment. There has been a puzzling disagreement in the results of spraying work, and the same material used at different times and in different places has not acted in the same manner. Broadly speaking, there is not

one of the usually recommended washes that has not achieved excellent results in some hands and in some localities, and, on the other hand, there is not one that has not failed as completely at other times in other places. Of course, in many instances the causes of individual failures were obvious or discoverable, but in some others the result or lack of effect is totally inexplicable. On a subsequent page are given the results of Mr. Dickerson's observations during his tours through the orchards of the State. On the whole it may be said that the scale is under better control than ever before.*

The *oyster-shell bark-louse* comes next in importance, and in a few instances has caused as much or even greater mischief than the pernicious scale. In an apple orchard in Burlington county this insect is actually more dreaded than the other and seems more difficult of control. It is on shade trees, however, that it is usually troublesome, and on shrubs in gardens, its range of food-plants standing second only to that of its pernicious ally. Nor is it confined to any one section of the State; reports from Warren and Sussex counties being as frequent as those from Burlington and Cumberland, although the infestation is usually on different plants. Insecticide applications are rarely made as against this insect, and that it does not spread faster and does no more injury is due to natural checks entirely.

The *Scurfy Scale* attracts attention here and there, but is rarely either very abundant or troublesome. Its occurrence during the past season on certain shade trees in Newark is exceptional, and apparently there was some difficulty in dealing with it.

The *Rose Scale* occurred in notable numbers in a few localities but chiefly in gardens and not on the berry plants that are sometimes so badly infested.

The *Cottony Maple Scale* reached the highest point in its development in 1905, and, as predicted in the previous report, it natural enemies obtained complete control of it in those localitie where it appeared first and in the greatest numbers. There is n doubt that the little lady-bird beetle, *Hyperaspis signata,* deserve the chief credit for reducing the insect to normal proportions, an

* In a very few cases the scale has disappeared from badly-infested tre where no treatment at all has been made, and this has raised hopes that might do so more generally, but there is no real evidence that this desirab consummation is anywhere near at hand.

Mr. Dickerson's observations, noted elsewhere in the report, will bring out this feature more clearly and in greater detail.

The *Maple Pseudococcus* started in large numbers and promised to become very abundant locally. It did, in fact, attract a great deal of attention, but, owing to a variety of causes, did not become as numerous as was expected. One of the causes, perhaps, was the fact that the lady-bird beetle, *Hyperaspis signata*, finding its normal food, the *Pulvinaria*, so much reduced in number, used the *Pseudococcus* as a substitute.

It was observed last fall that the insects crawled in great numbers from the upper parts of the tree to the trunk and got into the bark crevices to pass the winter. Taking advantage of this the trunks of the infested trees were sprayed with petroleum emulsion and many specimens were destroyed. As many of the insects fell with the leaves, however, and sought shelter on the ground and around the base of the trees, this method was not so completely successful as was hoped. It should be supplemented by gathering up and burning the leaves beneath infested trees as soon as possible after they fall, and by banding the tree to be protected by a complete coating of some sticky material which the insects cannot pass on their journey up the tree. On this point the notes under the heading shade tree insects should be referred to.

The *Tulip Soft Scale* was again somewhat widespread and troublesome, but, curiously enough, the greater number of complaints this past season came from the more northern sections of the State. This is an insect against which remedial measures are rarely taken, and are in fact rather difficult to make and unsatisfactory in results. Fortunately this species also is subject to parasitic attack, which, on the whole, keeps it down to inconspicuous numbers.

The *Peach Soft Scale*, an account of which was published in the report for 1905, was further observed during the past summer. No satisfactory applications were made in any orchard, and in most of the infested orchards no applications of any kind were made. In the course of his inspection work Mr. Dickerson noted the spread of the insect into adjacent orchards, so that gradually the entire district is becoming infested. Up to the present time no spread into new districts has been noted, and as the insect does not travel readily, there is no reason why, with a little care, it should not be confined to the territory now infested.

Orchard Insects.

The *plum curculio* has been as abundant as usual and has caused trouble on pear, especially the Keiffer, numerous specimens of which were found to be infested late in the season. Little attention has been paid to this habit—if indeed it be really the plum curculio that is at fault—because the trees of this variety are nearly always overloaded and the insect seems to develop only in the fruit that has dropped to the ground. It is a matter that needs further study, and, in any case, it is bad practice for horticulturists to allow fallen fruit to remain on the ground so generally. It may cost something to keep it picked up, but it will prevent the development of a great many curculios and perhaps other species as well.

The *apple borer* seems to have been unusually plentiful during the season on both apple and quince, and for the first time its injury was noted in the Experiment Orchard. With the increased care that orchards are now receiving almost universally, the occurrence of this borer is usually noted very promptly, and the larva is either cut out, destroyed by a wire or killed by means of bisulphide of carbon injected into the boring. The latter method is perhaps as effective as any and needs for an outfit a knife to clear the opening of sap and sawdust; an oil can with a slender spout, or a dropper with a rubber bulb to force in a little of the liquid; a supply of the bisulphide and a wad of putty or grafting wax to close the opening after the liquid has been injected. The vapors from the material will follow the boring and will kill the larva wherever it may be.

The record of the *Experiment Orchard* is less complete than in previous years owing to the fact that circumstances compelled me to let my place for a year, but the effect of the spraying work done in the fall of 1905 is noted, and the results of the neglect to spray with arsenites is well brought out in the large proportion of wormy and "stung" fruit which was noted.

The *pear blister mite* was more abundant and noticeable than it has been for some years past. Specimens were sent to the office in May and June, and it was noticed in the course of general examinations made in quite a number of the orchards. As a matter of fact very little actual injury was caused, and, though some badly-infested leaves turned black and fell, very little of it was seen later in the season.

Mites in general were very abundant on quite a variety of foliage and caused a good deal of spotting of leaves on peach, cherry, oak, chestnut and quite a number of other trees. These mites are very small creatures, generally known as red spiders, and they often do serious harm or cause a yellow, sickly appearance of the infested leaves. They are most abundant on the under sides and their eggs may be found on the bark of the twigs and branches

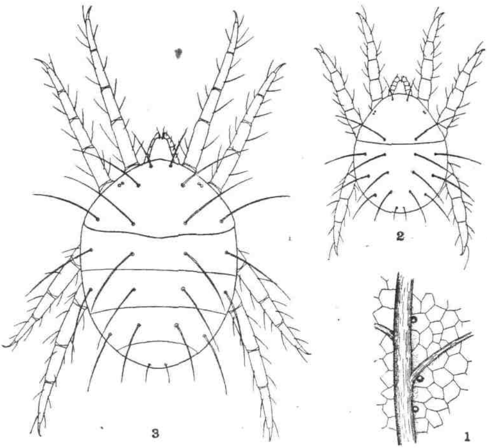


Fig. 1.

A mite: *Tetranychus mytilaspidis*. 1, the eggs on the under surface, usually laid close to a vein; 2, the six-legged young just hatched; 3, the adult mite, just visible to the unaided eye; much enlarged. Original.

during the winter. Sulphur is a very satisfactory remedy as against them, and any of the diluted sulphides may be employed as a spray. In the greenhouse flowers of sulphur may be dusted on the ground beneath infested plants.

The pear psylla.—In the report for 1905 mention was made of some Keiffer orchards in Cumberland county in which this insect had caused injury, and these orchards were revisited in March by

Mr. Dickerson. At that time the trees had been scraped and thinned by trimming, but no insecticide applications had yet been made. Numerous hibernating specimens had been observed under the loose bark and others were observed yet present in the crevices wherever examination was made. The owners were advised to burn all trimmings and scrapings and to apply petroleum in some form, driving the spray into the crevices with as much force as possible.

June 19th another examination was made, and it was found that the trees had been sprayed with a kerosene emulsion giving about 10 per cent. of actual kerosene. Examination made soon after the application showed that the insects had been killed wherever the mixture had reached them, but it was also found that by no means all of them had been reached. This was quite obvious also at the date first given, because specimens were found on both leaves and twigs, though in no great numbers. It was also learned that the pest had spread into other orchards and was obvious where none had been observed in previous years.

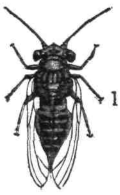


Fig. 2.
Pear psylla; wing adult; enlarged.

To reach this insect in its winter quarters is not altogether easy, for the adult crawls deep into every crevice or gets under every bit of available shelter, so that any ordinary spraying work will miss reaching it. Rough-barked trees should be scraped and trimmed in winter, and all the loose material should be burned at once. If it is allowed to remain for any length of time, the exposed insects on it will move away and seek other shelter and so will escape destruction, and the warmer the weather the sooner the insects will move, so that the leeway is greater in cold weather than in the warm sunshine of many March days. Kerosene emulsion or soluble oil should be applied very thoroughly, especially on the trunks and larger branches, so that all slits, cracks or crevices in the bark may be reached, and the greater the force of the spray the better the chance of a satisfactory result. Ten per cent. of actual oil will not be too strong and will give better results than a weaker solution, and if the spraying can be done on a warm, sunny day, just before the trees start, more insects will be reached than otherwise, because the oil spreads and penetrates better on a

warmed surface than on one that is dead cold. This insect is sufficiently destructive when present in large numbers to make it worth while for those fruit growers that are threatened to use effective measures to check it.

Insects on Field Crops.

The occurrence of the *army worm* at Woodbine in late August was interesting, because it was the first time since 1896 that the insect has injured field crops. It is occasionally found on grassy cranberry bogs and sometimes eats the vines when the grass has been destroyed, but on well-kept bogs, properly ditched, the injury is usually slight. As there is some reason to fear that the insect may appear again in 1907, and perhaps over a greater area, a brief record of this year's occurrence and some suggestions as to remedial measures are given on a later page.

Associated with the common species was the *fall army worm*, *Laphygma frugiperda*, which also seemed to be unusually abundant, but would not of itself have been noticeable or injurious.

The *corn-stalk borer* was not nearly so abundant as it was during the season of 1905. Nothing was added to the life history given in the last report and no experiments looking toward its destruction were made, nor was anything done by farmers, so far as I have been able to ascertain, so that the lessened numbers are due to natural causes alone. Some report of injury to corn was received, however, and near Newark the larvæ were found boring in bean and in pansy plants. There seems to be no reason to expect any immediate recurrence of the injurious increase of 1905.

Cabbage worms were abundant in many parts of the State and complaint of injury done by them was received as early as July 6th. As the season advanced the injury became more notable, and in early fall it was easy to recognize their presence by the ragged outer leaves into which holes of all sizes had been eaten. The methods of dealing with these insects are so well known and effective that it depends upon the farmer himself how much loss he suffers from them.

Grasshoppers were reported as being injurious in Morris county early in the season and occurred in great numbers near Chester, but before any serious harm had been done they became victims of disease, and in July many dead specimens were found clinging to the stalks of grasses, &c. Ordinarily, these insects do not become

at all numerous in our State until late in the summer or in early fall, and some diseased specimens are always found at that time. Nature has provided us with a very good natural check in this case which seems to become active under the same conditions that favor the development of the insects themselves.

Asparagus beetles seem to have been more abundant during the past season than for some time past. For several years very little trouble has been caused and very few complaints have been received. This year reports of injury came from several points, and they were noted as abundant in the course of field work, showing that some general conditions favored the increase of the insects.

Root maggots on onions and cabbages were very common in some localities and much damage was caused. The life history of these insects is pretty well known, but up to the present time there is no entirely satisfactory method of dealing with them. A series of experiments was planned early in the season, the co-operation of a number of growers was secured, and Mr. Dickerson was entrusted with carrying out the details of the work. While no final results have yet been attained, and some of the experiments planned could not be carried out because the materials were not all received in time, some progress was made and an account of the work done will be found on another page of this report.

Flea beetles of several varieties were locally troublesome and were reported in letters or noted in field work. Roses were injured in Bergen county by the red-legged beetle, *Crepidodera rufipes,* but the chief offender was the little black potato or tomato flea, *Epitrix cucumeris.* This has a wide range of food plants and is always more or less abundant. This season it got into young tomato plants and caused more or less damage. Finely ground tobacco was used with satisfactory results and can usually be relied upon to check the trouble. Since it has become the practice in some localities to spray the young plants with Bordeaux mixture there is very little complaint of flea beetle injury, this mixture also serving as an almost perfect protection.

Wire-worms have been locally troublesome and on a very great variety of plants. Potatoes always suffer to some extent and this year was no exception, but an attack on peach pits is added to the usual occurrences of the year. A nurseryman reports that they got into the planted pits in the nursery rows and destroyed a notable percentage of the young trees. Nothing new has developed in

the way of remedies and fall plowing of infested ground is still the most effective measure.

White grubs have been about as usual and have been complained of by strawberry growers more than any one other insect. Once the ground is infested very little can be done, but strawberries should never be set on old sod land recently turned; they should not be too liberally treated with stable manure, and they should not be allowed to become overgrown with weeds so as to attract the beetles that lay the eggs. In general, complaints are more numerous from the northern than from the southern part of the State. There is no greater enemy to the white grub than the hog, and a drove of hogs allowed to root for a week in an infested field will do more to clean it up than any insecticide application known.

Cut-worms were not more abundant than usual, but appear to have exacted no smaller toll than in other seasons. There is nearly always a short period when complaints are more or less numerous and little is heard later in the season. Gradually the growers of plants liable to injury are learning how to avoid trouble, and it is only when some unusual conditions arise that they are found unprepared. The only unusual report during the past summer was of an invasion of cranberry bogs in Burlington county, and, in this connection, a communication from Massachusetts indicates that some varieties of cut-worms may be responsible for a part of the injury charged to the so-called girdle worm.

Shade and Other Trees.

Shade tree insects continue to be objects of attention, and Bulletin No. 181, dealing with them, has been steadily called for until the edition is almost completely exhausted. The number of communities taking an active interest in the subject has increased, and on another page is given in more detail a record of the species that have proved troublesome and of the methods adopted by the various authorities in dealing with them.

The Catalpa Hawk-Moth, Daremma catalpæ has continued its northward and eastward spread and at present covers the entire State except perhaps Bergen county. The records obtained and observations made are positive for every other county, and it is more than probable that even Bergen has some centers of infestation which have not yet been reported to the office.

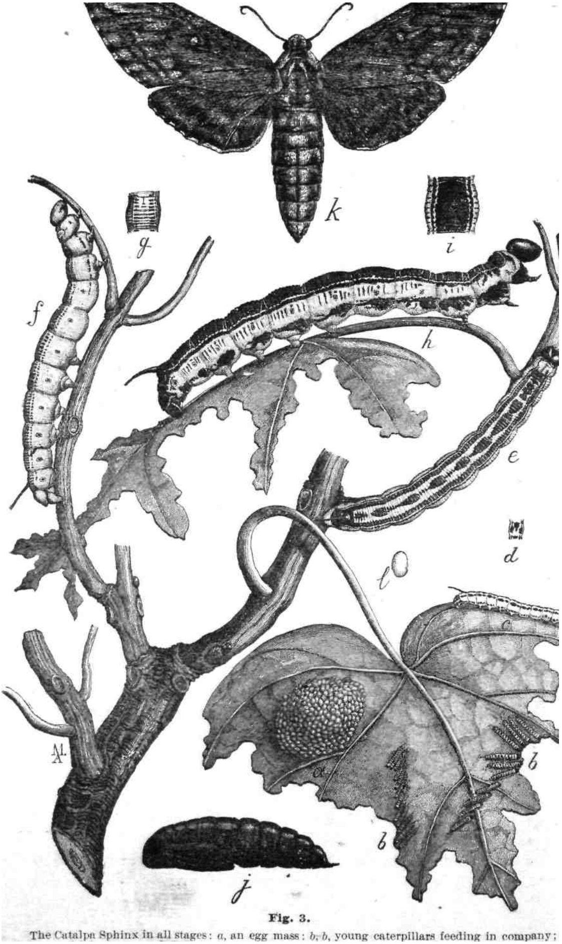


Fig. 3.

The Catalpa Sphinx in all stages: *a*, an egg mass; *b*, *b*, young caterpillars feeding in company;

is in the nurseries that the caterpillars cause the greatest mis-
, the large broods of caterpillars, unnoticed in their early
s, completely defoliating small or even large blocks in a few
before the nurseryman recognizes their presence or realizes
langer it involves. Smaller shade trees or larger single trees
infested by a sufficient number of specimens are stripped
in less than a week, and the specimens disappear before the
r gets ready to take active measures against them. The ex-
ation of this sudden appearance is that the broods are large,
he caterpillars from one egg-mass, 200 to 300 in number, feed
mpany on a few leaves until they are nearly one-third grown,
the loss of these few leaves is not noticed; then they separate
what and the individual eating is small until the caterpillar
arly half grown. At that time the insects feed most vora-
ly and continue until they reach their full growth, each de-
ing several of the large leaves in the course of a week. It is at
ime, when the leaves disappear so rapidly, that their presence
ually noticed.

to remedial measures, these are simple and effectual. In
ries a sharp lookout will detect the colonies soon after they
ut of the egg and before they have done much feeding. Pick-
ff a few leaves and crushing them under foot will then serve
estroy the entire brood, leaving the plants free until indi-
als of the next brood are on the wing. On shade trees and on
ry trees, if the caterpillars have begun to spread, spraying
arsenate of lead at the rate of five pounds to one hundred gal-
of water should be resorted to, and will prove effective if
ughly done and if the larvæ are not too nearly full grown. In
case the application should be made as soon as possible after
nsects are discovered.

e so-called *yellow-necked caterpillars*, the larvæ of *Datana*
es, have been rather plentiful on a variety of shade and other
, and their occurrence has given rise to one report of the occur-
of the Gypsy Moth. These insects feed in companies, closely
ed, and can devour an enormous amount of foliage in a very
time. They have one peculiar feature in common: when at
the middle legs only are used to hold on, while the head and
rior end of the body are elevated or held at an angle, free from
urface on which the insects are resting.

Grape Galls.

Bladder-like galls on grape are occasionally noted each seaso and in some years they are quite generally distributed and attra a great deal of attention. During the past season the trouble seen to have been quite generally distributed and reports have com from a number of localities, but chiefly the more northern sectio of the State. The trouble is due to a small midge, *Lasioptera viti* which lays its eggs in the tissue of the leaves, leaf stalks or eve the tendrils. When the egg hatches into a minute larva the pla tissue swells and forms a small or large swollen mass which, whe cut, is a sappy, cellular tissue with a central cavity for the larv A badly-infested vine presents a curious appearance in late May early June, and after a few days little round holes appear in th swollen masses. This indicates that the insects have reache maturity and very soon thereafter the swellings disappear leavin no trace, and without permanent harm to the vine.

Rose Chafer.

This species has continued to increase and was more widely in jurious than during the summer of 1905. At Vineland grape suffered severely, but the insects were very unevenly distribute and in some vineyards practically none at all were observed. Othe fruits suffered to some extent, but no notable damage was cause In this place, while they were more abundant than they have bee for years, they are not yet as abundant as they were in 1890. A Oceanic they were also injurious to grape and attacked other fruit as well. The flowers of the tulip tree are always very attractiv to the beetles, and on a poultry farm, where such a tree was in ot used as a chicken run, the owner shook down a mass of th beetles which were promptly snapped up by the chickens. As result twenty of them were dead next morning, and on cuttin open the crops these were found packed in a solid mass with th nsects. Ordinarily chickens do not touch the beetles at all, an whenever they do the result is apt to be bad, but ducks seem t manage the insects all right.

At Matawan strawberries were attacked and both foliage an ruit were eaten. At Elm, they were general in their feeding an

word was received that they had eaten up everything, but that may have been somewhat exaggerated. At Daretown, cherries suffered more than anything else; the other fruits were also eaten to some extent.

Mr. Dickerson's reports show that at various points throughout the State roses, apples and plums were more or less injured, and there is no doubt but that there is a general increase in their number and in the injury caused.

Arsenate of lead in heavy doses was tried in two instances, and in one case at least with a measure of success. In the protection of especially valuable plants or fruits this may, perhaps, prove satisfactory, but in the protection of an orchard or vineyard the expense would probably be too great. An attempt will be made next year, if possible, to test this material further.

Plant Lice.

Plant lice were nowhere very greatly abundant, nor did any especial crop suffer seriously, yet they did attract attention on a variety of plants and trees, and, on apples, were plentiful enough in a few localities to make the curled-up tips conspicuous. Other species brought to our notice in the correspondence during the season were on cherry, willow, hickory, elm, maple, melon, potato, strawberry and rose. Of the woolly lice, those on apple, alder and elm attracted attention and were reported upon. This is really an exceedingly good record for the season and shows it to be one decidedly unfavorable to the development of this type of insect.

Beneficial Insects.

Nothing was seen or heard of the *Chilocorus similis* as an enemy of the pernicious scale, and no especial search was made just where the insects had been placed, although examinations nearby would have discovered them had there been any spread. As a check to the insect against which they were introduced they may be accounted a failure, and I am not aware that in other States their success has been greater.

The little *Pentilia misella*, on the other hand, has been present everywhere, and in some places in very great numbers. Hun-

dreds of larvæ and adults were seen on individual trees, and there is no sort of doubt that this is a very real check to increase, though not yet sufficient for control. As these insects were seen in sprayed as well as unsprayed orchards, there seems to be a chance that the species will eventually prove an effective aid in disposing of those specimens that escape the most thorough winter work.

The *Chinese Mantis* has a precarious hold, and occasional specimens are taken by collectors. It has certainly not become numerous enough to be of any use. Early in December Mr. Phil. Laurent again offered to secure egg masses for us, and by the 16th of that month three hundred had been received. Two of these masses were tied out next to the Experiment Orchard, and one nearly full-grown specimen was observed during the summer. The balance of the eggs were tied out in the Orange mountains by Messrs. Brehme and Dickerson, near South Orange.

It was determined to give these insects every chance that a large colony would offer to sustain themselves, and to find mates if even a small percentage only survived. The place selected was a secluded spot on top of the mountain, perhaps an acre or two in extent, overgrown with rank vegetation and bushes, and almost surrounded by woods. It was an ideal place for insects, and there, if anywhere, it was believed, the Mantids would be able to find a living. The egg masses were tied on the bushes and tall plants, usually about a foot or thereabouts from the surface. This low position was chosen because some of the masses in previous years had been apparently picked by birds, but the new location was even worse, because when in early spring an examination was made, it was found that field mice had eaten out the great majority of all the masses. Whether enough have escaped to form a colony cannot be positively determined as yet.

Miscellaneous.

Among the other insects that were sent in for determination and which were locally troublesome were, among the beetles, borers of various kinds in maple, in grape buds and in some shade trees, the "Buffalo moth," the fruit tree bark beetle, a bark beetle on maple and the Indian Cetonia.

Among the *Lepidoptera* were the cranberry moths, the peach

borer, the *imperialis* caterpillar, the *io* moth, the *cynthia* moth on *Ailanthus*, a small larva on the leaves of tulip trees, an undetermined caterpillar on chestnut, the *Sphinx* larvæ on tomatoes, the *inclusa* caterpillars on poplar, the wood leopard moth and the Tussock moths.

Among the *Hemiptera* or true bugs other than the plant lice were spittle insects, *Aphrophora parallela*, on pine, the various orchard and shade tree scales, and Thripids on peach and on greenhouse plants. On the latter, by the bye, cold water was applied with good results.

Among the *Hymenoptera* were ants of several species infesting lawns and injured trees, some oak galls and the Pigeon Tremex.

Among the *Diptera* or flies were the Hessian fly, the wheat stem maggot and certain fungus gnats.

Insecticides and their action continued to form one of the subjects to which attention was directed, and a considerable number of direct experiments were made under supervision of the Entomologist, and a much greater number of what may be called field trials by practical fruit growers and farmers were carefully observed as to methods of application and results. These observations are reported upon, partly under the general head of Insecticides and partly in the record of observations made on the root maggots.

Owing in part to ill-health, the Entomologist was accorded a long vacation so that the practical work of carrying out the planned experiments and the making of records of results fell largely upon Mr. E. L. Dickerson, assistant to the State Entomologist, who is credited in the body of the report with the specific worked looked after by him.

No bulletins were issued during the year from the date of the last report, but, as already stated, material is in hand for an essay on Root Maggots. Miss A. E. Meske is still office assistant and stenographer, and, with Mr. Dickerson on the staff of the State Entomologist, whose report is made to the State Board of Agriculture.

The equipment of the department has been fully kept up, and minor additions are constantly made as they are brought to our attention. The collections have increased in extent and variety, and further boxes have been prepared for the State Museum at

Trenton, as will appear in the report of the Curator, Mr. Silas] Morse.

The session of the Horticultural Inspectors held at the city Washington during the middle of November was attended as re resentative of the New Jersey Stations, and a trip was made in the newly-developed apple-growing districts near Martinsburg, V Va., where also the works of the American Horticultural Distri uting Company were visited and their method of making insec cides--Target Brand Emulsion and Arsenate of Lead—was o served. Some of the information gained will be found on anoth page of this report.

The usual work of attending institute and other farmers' mee ings throughout the State has been continued, and many lectur have been given, not only on the general topics dealing with insec injurious to crops, but with the mosquito pest in all its variation So, also, continuing good relations have been maintained wi entomologists and entomological societies, as heretofore.

Mr. John A. Grossbeck, assistant in the mosquito investigatio has materially assisted at times in the general work of the Statio and to his artistic skill the illustrations in this report will testif

The correspondence of the office during the past year was som what less than usual, owing to my long absence from office wor covering 1654 pages of letter-books and representing about 25(individual communications.

RECORD OF THE EXPERIMENT ORCHARD.

All the trees were sprayed with "Scalecide," 1 to 20, on N vember 16th, 1905, by Mr. Dickerson, who made the followin note: "This afternoon sprayed all the trees in the Experime Orchard with Scalecide at a strength of 1-12, and sprayed tho oughly except a few along the fence on side next to the stree These were pretty thoroughly sprayed, but difficult to spray fro both sides."

A few days later another application was made to the trees n properly treated, and there was a general touching up of trees th seemed to need it. Apparently no memorandum of this applic tion was made.

For personal reasons, my house and grounds were let durin

1906, and no further applications of any kind were made between the time above mentioned and November 1st, 1906. I did not personally see any of the trees during that same period, but Mr. Dickerson examined them at intervals and recorded as follows:

July 2d.—Looked over the trees and found them in the following condition:

TREE 1—*Mariana Plum.* General appearance good, and making good growth; very few plums on tree; a few of the leaves eaten by the rose chafer; very few scale larvæ or recent sets observed.

TREE 2—*Yellow Transparent Apple.* General appearance good; four good apples observed; leaves in many cases show effects of leaf hopper; *Pentilia* seen on one of the branches, as well as woolly lice on a few of the knots; very few scale larvæ or recent sets observed.

TREE 3—*Black Tartarian Cherry.* In good condition, without any signs of larvæ or recent sets of scale.

TREE 7—*Champion Peach.* Some twigs and small branches throughout the tree dead; lower branches well loaded with fruit, some of which were "stung;" scale apparently cleaned out.

TREE 8—*Grimes' Golden Pippin.* General appearance good; few apples, mostly in good condition, but some showing work of codling moth and curculio; apparently little or no live scale; no crawling larvæ or sets observed.

TREE 15—*Japan Golden Russet Pear.* General appearance of tree good; plenty of fruit on tree and scale apparently cleaned out.

TREE 16—*Japan Golden Russet Pear.* In same condition as No. 15.

TREE 17—*Trellised Peach.* Pretty well set with fruit, but about every one "stung" at least once and many more than once; live scales apparently very scarce.

TREE 18—*Vermont Beauty Pear.* A little live scale on this tree and most apparent on pears, some of which have at least a dozen sets. There is quite a setting of fruit, some of which also shows signs of curculio.

TREE 19—*Vermont Beauty Pear.* This tree is in just about the same condition as No. 18, but on a couple of small limbs toward the house there is quite a sprinkling of larvæ and recent sets; the branches must have been missed in spraying. There is rather a

light set of fruit and there were some webs of the fall web-worm which were removed.

TREE 20—*Meech Quince*. General appearance good; very little live scale observed; web-worms on one limb, next to No. 19.

TREE 23—*Greensboro Peach*. General appearance good; well set with fruit; no live scale observed.

TREE 24—*Greensboro Peach*. Similar to No. 23; but a portion of the fruit dried up when small; larvæ and sets very scarce.

TREE 25—*Apricot*. General appearance good; scale pretty thoroughly cleaned out.

TREE 26—*Nectarine*. Some dead twigs and shoots which should be cut out, but making good new growth; leaves not particularly smooth; scale apparently cleaned out.

TREE 29—*Gravenstein Apple*. Very little fruit and part at least is "stung" and wormy; some drops on ground; scale apparently pretty well killed.

TREE 30—*Grimes' Golden Pippin*. General appearance good; small crop of fruit, nearly every one stung and many wormy; apparently free from live scale.

TREE 31—*German Prune*. General condition good; well set with fruit, but hardly one which has not been stung. Plant lice have been pretty thick at tips of some branches, but now are pretty well dried up and dead. Scale has been apparently killed.

TREE 32—*Mountain Rose Peach*. General appearance good with a light crop of fruit; apparently little or no live scale.

TREE 33—*Dwarf Duchesse Pear*. General condition good and making good growth; very little fruit; no scale larvæ or sets observed and live scales apparently cleaned out.

TREE 35—*Japanese Walnut*. General appearance good; a few scale larvæ and sets observed.

TREE 38—*Baldwin Apple*. Has a good, rank appearance; very little fruit; scales apparently dead.

TREE 42—*Elberta Peach*. In good condition with small crop of fruit; no signs of crawling larvæ or live scales.

TREE 43—*Early Richmond Cherry*. Tree in good condition with no signs of scale upon it.

TREE 44—*Elberta Peach*. Foliage rather thin, but looking fairly well and well set with fruit. Some dropped fruit and a little dry rot; scale apparently killed.

TREE 46—*Japanese Chestnut.* In good condition, with several blossom clusters; apparently no scale.

TREE 47—*Greensboro Peach.* In good condition, free from scale, with a heavy crop of fruit.

TREE 48—*Black Tartarian Cherry.* Tree in good condition.

The notable features of this record are the large measure of freedom from scale and the large amount of "stung" and wormy fruit. Only on those trees—Vermont Beauty Pear—that were badly infested last season was any notable remnant present, and this was due to the fall application of 1 to 20 Scalecide. The absence of the usual arsenical sprayings is very well shown by the infested fruit and by the presence of the web-worms.

July 23d, word was received that some of the peach trees were overloaded and breaking, so Mr. Dickerson and Mr. Grossbeck went up, and did as follows:

TREE 7—*Champion Peach.* Picked off a large grape basket of green peaches and left enough to tax the tree on the bearing branches.

TREE 23—*Greensboro Peach.* Branches bent over with weight of fruit; picked off more than two-thirds of a basket of ripe fruit and left nearly as much remaining. Fruit of good quality.

TREE 24—*Greensboro Peach.* Branches bent down with weight of fruit; topmost branches broken off. Took off three-fourths of a basket of peaches, mostly ripe and of good quality, and left on half a basket more.

TREE 44—*Elberta Peach.* Dead or dying; all leaves off. Report of tenant was that it got into this condition about the middle of the month.

This is one of the trees that became so badly infested in 1903 that it was dehorned or cut back to stubby branches from the trunk. It did well in 1904 and made a heavy crop in 1905, which rotted before it ripened. It went into the winter in apparent good condition, but was already off color when Mr. Dickerson saw it in the early part of the month.

TREE 47—*Greensboro Peach.* Loaded with fruit and two small top branches broken; picked off a basket of ripe peaches, of good quality, and left half as many more on the tree.

Further examinations were made August 8th, and again October 20th, no applications of any kind having been made in the

intervening period. The conditions found on the two dates are recorded as follows:

TREE 1—*Mariana Plum.* August 8th, condition good, growing well, scales very scarce. October 20th, very free from scale and in good condition.

TREE 2—*Yellow Transparent Apple.* August 8th, very free from scale and growing well. Quite a few leaf hoppers—nymphs and adults—and almost every leaf shows the effect of their work by the discolored upper surface. October 20th, a very little setting of scale; the leaves, which to a large extent remain, show leaf-hopper injury to a marked extent.

TREE 3—*Black Tartarian Cherry.* August 8th, condition very satisfactory. October 20th, in fine, thrifty condition.

TREE 7—*Champion Peach.* August 8th, looking well and very free from scale; the thinned fruit developing nicely. October 20th, apparently very clean; on a few of the leaves near the trunk were signs of red spider and some specimens were yet present.

TREE 8—*Grimes' Golden Pippin.* August 8th, making a good growth, and very free from scale. Leaves badly discolored by leaf hoppers. October 20th, leaf-hopper injury very apparent on most of the leaves; very slight setting of scales on such branches as I was able to examine.

TREE 15—*Japan Golden Russet Pear.* August 8th, was in good condition, making good growth, very free from scale and with plenty of fruit. October 20th, plenty of ripening fruit; enough to break a couple of limbs; very little, if any, scale.

TREE 16—*Japan Golden Russet Pear*—Same record as for the preceding.

TREE 17—*Trellised Peach.* August 8th, not particularly thrifty; all of the fruit rotted; plenty of old scale covering, but very few living insects. October 20th, scale infestation very slight; red spider present on some of the leaves.

TREE 18—*Vermont Beauty Pear.* August 8th, doing fairly well, with a light set of fruit; while many of the pears are clean, there is a little setting of scale on some around the blossom end and quite a sprinkling of fresh sets on the tree. October 20th, leaves were about all off and there was a scattering infestation, including some fresh sets; some of the scurfy covering of last year's infestation killed by the spray was still present.

TREE 19—*Vermont Beauty Pear.* August 8th, conditions very similar to No. 18, but on a couple of branches quite a little scale infestation; from one branch two small nests of fall web-worms were removed and the tip of one branch has blighted back about eighteen inches. October 20th, similar, still, to No. 18, with more foliage remaining and more scale on some branches than were present at last inspection.

TREE 20—*Meech Quince.* August 8th, doing well and very free from scale; a few tips blighting; small set of fruit. October 20th, was no worse than before.

TREE 23—*Greensboro Peach.* August 8th, fruit all off; looks well; making a good growth, and keeps very clean. October 20th, was still good, and scale infestation very slight.

TREE 24—*Greensboro Peach.* Conditions on both dates were very similar to those on No. 23.

TREE 25—*Apricot.* August 8th, was making a heavy growth of top; was looking well, and was very free from scale. October 20th, matters had not become worse.

TREE 26—*Nectarine.* August 8th, a few small branches dead, apparently killed by heavy scale infestation of last year, else now in good shape, making fine growth, with very little scale and one fruit. October 20th, matters were no worse, and the tree was doing well.

TREE 29—*Gravenstein Apple.* August 8th, no fruit left; very free from scale; most of the leaves more or less injured by leaf hoppers. October 20th, was apparently doing well, and with a slight setting of scale; work of the apple borer was in evidence near the ground; the several borings were examined, treated with carbon disulphide and plugged with cotton saturated with it. In one boring a nearly full-grown larva was destroyed.

TREE 30—*Grimes' Golden Pippin.* August 8th, in good shape, but foliage spotted by leaf hoppers; no scale on fruit, which is nearly all wormy, and some injured by curculio. October 20th, conditions were no worse, and the tree was practically free from scale.

TREE 31—*German Prune.* August 8th, was in good condition; looking well, and practically free from scale; fruit clean; some has dropped; is now ripening; some of it stung. October 20th, continued in good condition, but has a scattering set of new scales.

TREE 32—*Mountain Rose Peach.* August 8th, was looking and growing well; very free from scale; fruit coloring up and maturing well. October 20th, was still doing well, and continues very free from scale.

TREE 33—*Dwarf Duchesse Pear.* August 8th, was doing fairly well; very free from scale; very little fruit; slug work present on a few of the leaves. October 20th, was just beginning to show a slight infestation of new scales.

TREE 35—*Japan Walnut.* August 8th, in fine condition, and apparently very free from scale, but now so large that it cannot well be examined. October 20th, was certainly no worse.

TREE 38—*Baldwin Apple.* August 8th, was doing well, and very free from scale; leaves pretty well spotted by leaf hopper. October 20th, was no worse than at last inspection.

TREE 42—*Elberta Peach.* Very free from scale, and looking fairly well, but foliage too light in color; small crop of fruit. October 20th, was still very free from scale, but the leaves showed injury from red spider.

TREE 43—*Early Richmond Cherry.* August 8th, the tree was doing well, and was free from scale, and on October 20th conditions had not changed.

TREE 46—*Japanese Chestnut.* August 8th, there was a small crop of nuts and no scales, but the foliage seemed a little dry, and was too light in color. October 20th, the injury to foliage was seen to be due to red spider, which had been very bad on this tree, sucking the life out of the leaves and causing them to dry and fall.

TREE 47—*Greensboro Peach.* August 8th, fruit all gone; tree looking well and free from scale. October 20th, conditions were no worse.

TREE 48—*Black Tartarian Cherry.* Continued to look well, and was free from scale throughout the entire season.

Mr. Dickerson's comment on October 20th is that "the orchard has remained in good condition, on the whole, all summer, and, with the exception of the Vermont Beauty Pears, very free from scale."

The lack of attention and spraying with the arsenites favored the development of slugs, web-worms, codling moths and curculios, while the red spider could have been kept in check with an oil emulsion or one of the sulphur sprays.

ENTOMOLOGY IN THE CROP BULLETIN.

The Crop Bulletin issued by the State Weather Service was discontinued at the end of the season of 1905, and its place is taken by the Crop and Agricultural Bulletin of the New Jersey State Board of Agriculture. This is issued monthly, instead of weekly, and the reports, so far as the insects are concerned, do not present so complete a picture of the season's happenings.

In May, the *San José Scale* was working fatally in all unsprayed orchards near Park Ridge, Bergen county; it was also rampant near Baptisttown, in Hunterdon county; near New Market, in Middlesex county, the fruit did not look well on account of the scale, and not much spraying had yet been done in that locality. At Freehold, Monmouth county, the prospect for fruit was good where the trees were well cared for and sprayed. Scalecide was used for the scale in place of the salt, sulphur and lime. Near Moorestown, Burlington county, apples, where not too much injured by scale, looked promising.

Flea beetles were eating tomato plants near Hopewell, Mercer county. At Imlaystown, Monmouth county, apple trees were full of fruit, but the *caterpillars* were almost stripping the trees of their leaves. *Cut-worms* were exceedingly abundant and destructive at Mount Laurel, in Burlington county. Potatoes were full of *bugs* at the same place, and much the same report came from Green Creek, Cape May county. *Lousy corn* occurred at Shiloh, in Cumberland county, and the *Curculio* was abundant at Cologne, Atlantic county.

In June, at Locktown, in Hunterdon county, hopes were entertained that the *scale* was being controlled; but at Athenia, Passaic county, the coming fruit crop was estimated low because of scale injury. *Potato beetles* continued to be numerous at Locktown; they had been very bad at Dutch Neck, in Mercer county, and were exceptionally bad near Moorestown, in Burlington county. *Rose bugs* damaged, and in some instances completely destroyed, sweet cherries near Park Ridge, Bergen county; they cut into the raspberry crop at Hammonton, Atlantic county, and were very destructive to cherries near Shiloh, in Hunterdon county. *Peach* and *squash borers* were reported as apparently exterminated by weather conditions at Dover, Morris county. *Worms*

in cherries lessened the crop at Cranford, Union county, where the non-occurrence of the Periodical Cicada is also made a matter of positive note. *Cut-worms* were charged with a loss of twenty-five per cent. of the cabbage crop at Athenia, Bergen county; they compelled the replanting of tomatoes and troubled corn near Hopewell, in Mercer county; kept back corn near Moorestown, and delayed the starting of gardens at Mount Laurel, both in Burlington county; finally, small caterpillars were charged with causing a bad dropping of the leaves of Norway maples at Hopewell, Mercer county.

In July, *Scale* ravages were not showing as bad as in the two last preceding years, which may be due to the fact, which was also noted, that some spraying had been done, near Morristown, in Morris county. *Wormy apples* were reported from Matawan, Monmouth county, which may, in part at least, be explained by the further report, "no spraying of consequence done here."

In September, *San José Scale* threatened the total destruction of the apple industry at Baptisttown, Hunterdon county; many apple trees were dead through it at Preakness, Passaic county, and blight and scale together caused light crops of apples and pears at Hopewell, Mercer county. It is comforting to learn, from Livingston, in Essex county, that the fruit was clean and showed no signs of scale.

In October, Park Ridge, Bergen county, complains of two things—"increasing taxation, with but little to show for it, and the San José scale, with too much to show for it." That all is not yet lost is shown by the added note that "very many will spray in the fall, as well as in the spring." At Cohansey, Salem county, late-threshed wheat was badly cut by the *grain moth*, and much of it was not fit for flour.

THE ARMY WORM.

Leucania unipuncta Haw.

This insect is rarely troublesome in New Jersey, although the adult moth is one of the commonest of its tribe found by the collector. Its normal food plants, the grasses, are, however, so plentiful everywhere that a great number of individuals develop absolutely unnoticed every season. They are kept in check as a rule by parasites, to which they are greatly subject, and by diseases

which attack the caterpillars and prevent them from reaching their full development. Occasionally these checks are wholly or partially absent, either locally or over a considerable territory, and then the species increases rapidly and becomes more or less injurious.

Usually it is when a dry autumn is followed by a moderately severe winter and a dry spring that danger may be expected, but there seems to be no absolute rule in the matter.

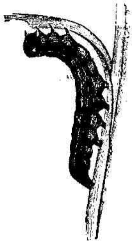


Fig. 4.
The Army Worm. After Riley.

In 1889 the species was troublesome in a few localities, and in 1896 it appeared in several sections of the State, the reports for these years giving details of the injuries done. Since that time, and until the past summer, no complaints were received, but near the end of August the caterpillars were found at Woodbine, Cape May county, and Mr. Dickerson went down September 1st to investigate. It was found that the crops on about ten acres had been pretty thoroughly destroyed, and damage to the extent of several hundred dollars had been done. According to Professor Pincus, of the Agricultural School, the caterpillars had been observed in small numbers in the German millet about ten days previously, but on account of rainy weather they were not again observed until a week later, when it was found that they had done considerable damage.

After so eating the German millet that there were only long stubbles left, they migrated on the one side into the field of Japanese millet, destroying that, and then into a field of corn next to that. On the opposite side they entered a field of corn and had already injured a few rows. On the third side of the German millet they crossed the road and established themselves in a field of cow peas and kaffir corn. They ate the corn and left the peas, apparently avoiding leguminous crops. The fourth side of the millet field first infested adjoined a piece of scrub land, which the larvæ did not enter. There was a small plot of German millet a short distance from the general infested area, and that also was eaten up. The Japanese millet was more mature than the German variety, and on this the head as well as the stalk was left.

At the time of Mr. Dickerson's visit most of the caterpillars

were nearly full grown, but quite a number of small specimens remained, capable of considerable mischief. A number of the caterpillars were brought back to the laboratory, and more than half of these developed normally into moths a short time afterward.

When the office was notified of the occurrence of the insects, ditching and spraying were recommended, and this recommendation was followed. Mr. Dickerson found that ditches nearly a foot wide and one and one-half feet deep had been dug around the

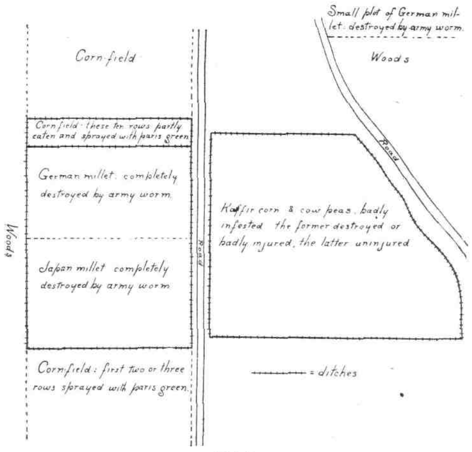
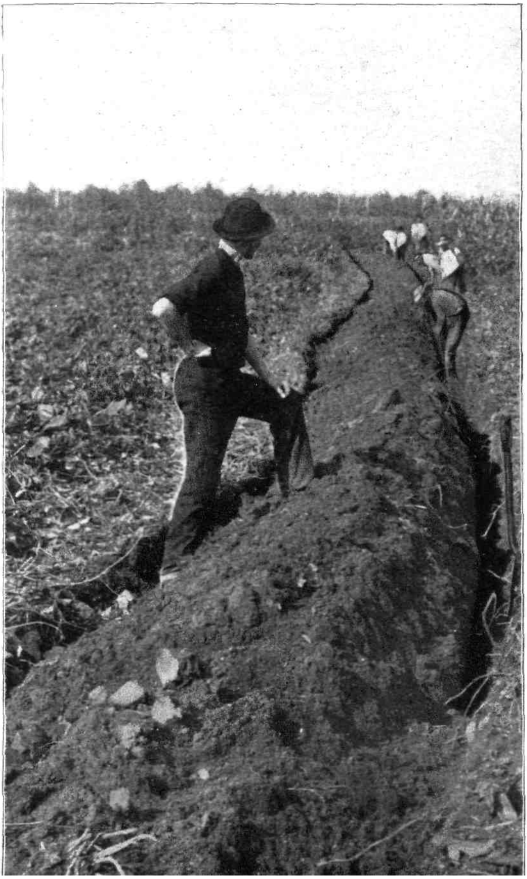


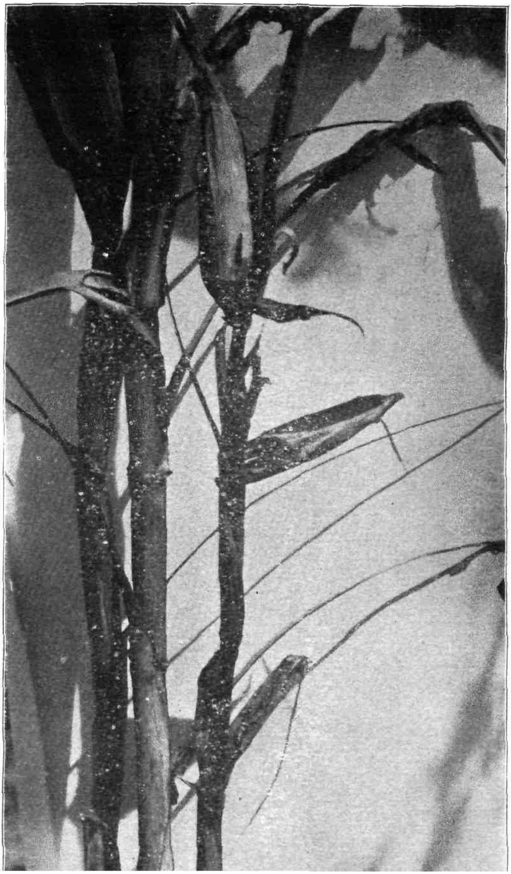
Fig. 5.

Plan of area invaded by Army Worm at Woodbine. Original.

infested areas to prevent further migration. Thousands of caterpillars were already in them, unable to crawl out, but they were sprinkled, nevertheless, with kerosene to prevent the development of those that were already mature and ready to pupate. The rows of corn to which the larvæ had penetrated before the ditches were dug were thoroughly sprayed with kerosene.

Quite unusually the caterpillars were free from parasitic or disease attack. While in previous invasions which I had observed the





vast majority of all the larvæ were parasitized, this time parasites were almost absent, and all the larvæ brought in pupated, although not all reached the adult stage. The only disease present was where the larvæ were crowded in great numbers on corn, when veritable decaying masses of them were lodged at the bases of the leaves and close to the stalk.

This absence of parasitism and disease leads to the fear that, if the spring of 1907 is favorable, the insects may appear in yet greater numbers and over a larger extent of territory, hence a brief account of the life history and of the methods adopted to prevent injury are here given:

Life History.

The adult is a so-called "miller" or owlet moth, such as is often attracted to light on hot, sultry nights; of a dark reddish clay color, powdered with black atoms, and a little white spot near the middle of the fore wings, from which the name is derived. It is in this moth stage that the insect usually lives through the winter, or hibernates, although hibernation in the pupal stage is not uncommon, and it may also occur in the larval stage.

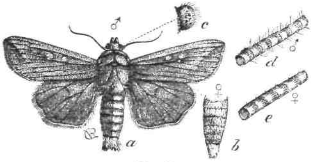


Fig. 8.

Leucania unipuncta: parent moth of Army Worm, with some details of structure. After Riley.

This moth, whether it hibernates or whether it emerges from the pupa in early spring, lays its eggs on grass or grain, favoring under ordinary circumstances the rankest and densest growth, because it finds there the best shelter for the five to eight hundred eggs which constitute the supply of one female. The eggs are laid close together, in series of twenty or more, and are covered with a whitish, adhesive fluid, which fastens them to each other and holds them in position on the grass blade. They hatch in about a week from the time they were first laid and produce a dull reddish or brown caterpillar marked with yellow and black longitudinal lines. Growth continues until these caterpillars become nearly two inches in length, and then they make their way to the ground and change

to mahogany brown pupæ about two inches below the surface—le in summer than in late fall, when they usually go nearer the fro line. In from one to two weeks afterward the adults make thei appearance and soon thereafter another life cycle begins. Unde ordinary circumstances, six weeks from the egg to the resultin adult may be considered about normal, but in midsummer th period may be shortened to a month, and in cool weather may b lengthened to nearly double that time. Three broods during th season are usual, although there may be a partial fourth, whic matures so late that many of the pupæ hibernate.

It is rare for the spring brood to be sufficiently numerous t become noticeable, and even the second or early summer broo rarely attracts much attention, but in late summer, when the thir brood in a favorable season becomes half grown, they are present i such enormous numbers that in a few days an entire field is cu down and a march is begun. These "armies" on the march follo no order or system; it is merely a search for food, and each indi vidual halts as soon as it has found something to feed upon, resum ing its place in the line as soon as hunger can no longer be satisfie While they occur in moderate numbers the larvæ usually feed a night and hide at the base of the plants during the day, but whe their numbers become so great that the food-supply is scant the eat at all times when opportunity offers.

Remedial Measures.

It has been stated that the adult usually lays its eggs in th densest and rankest part of a grain or grassfield, and it is fro such spots that the insects usually spread or from which an "army starts. When such an infested patch is discovered, it should b isolated at once by plowing a deep furrow completely around it steep side outward. If the furrow is imperfect, mend with a spad so that the caterpillars may find it impossible to crawl out. A ditch may be dug instead, if more feasible. At intervals of ten fee or thereabouts drive post holes or dig a deeper hole. The cater pillars having entered the furrow or ditch, and finding it difficul to scale the further side, naturally crawl along the bottom until a post hole is reached. They tumble into that and are then utterl unable to escape. To prevent any from maturing, kerosene may b

poured into the holes once or twice a day, until no more caterpillars are in the ditch or furrow.

Having isolated the infested area, if the plants are corn, they may be heavily sprayed with arsenate of lead, one pound to ten gallons of water, to kill the caterpillars feeding on them. Arsenate of lead is recommended because it may be used very strong without causing injury to the plants, but Paris green, one pound in one hundred gallons of water, will answer as well, except that it will burn the leaves to a greater or less extent. Spraying wheat, millet or other narrow-leafed grasses with arsenites is not recommended, because of the difficulty in making the material stick, but kerosene may be used to good advantage if the crop is so far gone as to be valueless.

If the caterpillars are less than two-thirds grown, advantage may be taken of their fondness for bran, and dry bran mixed with white arsenic, at the rate of one pound of arsenic to fifty pounds of bran, may be scattered liberally over the ground or among the plants. Paris green, at the rate of one pound to twenty-five pounds of bran, will do as well. Most of the caterpillars tend to get down from the plants during the middle of the day, and will find the bran before they climb for another meal. Where a brood is discovered early, this poisoned bran treatment may be all that is necessary. Where the insects are not discovered until they have begun to spread, the first thought should be to limit them by the furrow as already described.

Natural Enemies.

It has been stated that the caterpillars this year were unusually free from parasites. This statement is based partly upon the laboratory results and partly upon the fact that no eggs of *Nemoraea leucaniæ* Kirkp., were noted on them. This *Nemoraea leucaniæ* is a good-sized bluish fly, something like the ordinary blue-bottle in appearance, and it lays its white eggs on the back of the caterpillar just behind the jaws or legs. These eggs are easily visible and their practical absence this year indicates a very heavy brood of late adults and may mean danger next year.

In the ditches a few examples of caterpillar hunters—large predatory beetles of the genus *Calosoma*—were observed, but not in sufficient numbers to have any perceptible effect in reducing the number of "worms."

THE GYPSY MOTH.

Porthetria dispar Linn.

In the report for 1905 there is an account of this insect, with a history of its spread in the United States, the injuries caused by it and the menace of its introduction into New Jersey. It was not known at the time that as a matter of fact the insect had been already introduced into the State by an experimenter, who had, as he believed, perfected a method for its destruction.

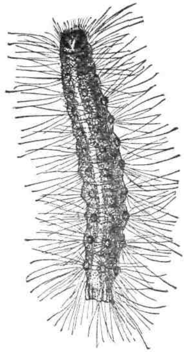


Fig. 9.
Caterpillar of Gypsy Moth; full grown. From Div. Ent. U. S. Dept. Agl.

The matter came to the attention of Mr. A. H. Kirkland, superintendent for suppressing the gypsy and brown-tail moths in Massachusetts, and he at once communicated with the office. Mr. Dickerson, who was in charge during the absence of the entomologist, at once visited the point where the introduction was made, found that there was no immediate danger and left the matter for further investigation later.

On my return, in early April, I took the matter up at once; found that during the winter of 1903-1904 a resident of Madison, developing an insecticide, was induced by a friend to try it on the gypsy moth, egg-masses of which were sent in by mail for that purpose by the obliging friend. The egg-masses were received very early in spring, were hatched in a greenhouse before any vegetation had started outdoors, and the caterpillars were fed on dwarf maples until outdoor foliage was available. When the larvæ were half grown the poison was tested, and a large proportion were destroyed. Finally, all remaining larvæ were destroyed and the greenhouse was fumigated with sulphur before it was opened for the summer. I was assured that no eggs were placed outdoors and no larvæ were allowed to escape. Also, that only one lot was received and all were used in the one place, near Stanley, in Morris county.

Under my instructions, Mr. Dickerson went to Stanley, July 3d, armed with a powerful Zeiss stereo-field glass, and reports as follows: "I drove directly to the greenhouse, looked carefully around it in all directions, in the lots and woods which surround it. I also followed out the various roads for a considerable distance, but nowhere could I see any signs of caterpillar injury—in fact, the vegetation and trees seemed unusually free from infestation."

On August 6th Mr. Dickerson again visited the locality, and was then accompanied by Mr. Grossbeck. His report continues: "This time, after looking carefully around the greenhouse, we drove along the various roads passing by or near it, and went much further than on the first visit. Mr. Grossbeck kept a close lookout

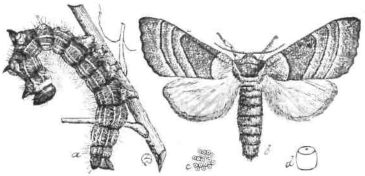


Fig. 10.

Yellow-necked Caterpillar (*a*) and its parent moth (*b*); eggs (*c*), natural size and (*d*) enlarged. After Riley.

on the trees and bushes on one side of the road and in this way we covered the ground very completely. The results were similar to those of the first visit; the trees were exceptionally free from caterpillar attack and no signs of the gypsy moth were observed." It should be said that for a space of several hundred feet from the greenhouse the ground was covered, on foot, in every direction, and the driving was a slow walk, with frequent stops to investigate suspicious appearances.

July 27th, Mr. Kirkland again communicated with the office, enclosing a clipping from the Springfield, Mass., "Republican," which recorded the appearance of the gypsy moth in Trenton. A similar note appeared in the Boston "Globe" of July 22d, and this was furnished by the Associated Press, through the New York "World."

The matter was investigated by Mr. Dickerson and traced to the Trenton "Times," from whom he obtained the name and address of the person who observed the insects. The place was visited and carefully inspected early in September. No trace of the gypsy moth in any stage was observed, and from the description that was given of the caterpillars, it appears certain that a species of *Datana* was in fault, the caterpillars resembling those of the gypsy moth to a considerable extent. At all events, it seems reasonably sure that up to the present time the gypsy has not actually appeared within our limits.

Several inquiries have come from different parts of the State asking information concerning the insect, and specimens as unlike as the caterpillar of the *imperialis* moth have been sent in to determine whether or not it was the gypsy or brown-tail.

Reports of the occurrence of the insect in New York City were investigated by the local authorities and proved unfounded, but at Stonington, in Connecticut, a colony has been found and observed by the entomologist in that State and by agents of the United States Department of Agriculture.

ROOT MAGGOTS.

Maggots on the roots of onions and on the various cruciferous plants are more or less troublesome each year, sometimes locally, sometimes throughout the entire State, and there are no insects that are more difficult to deal with. I have kept track carefully of the experimental work done throughout the country and of the various applications made in our own State in the hope of gaining some information that would enable us to deal with them more certainly and effectively. It is remarkable what a large number of remedial measures have been proposed, how successful they seem to have been in some cases and what failures they have been with others. It is also puzzling to find that conditions of soil and locality seem to affect the action of the materials in a varying way, and how apparently eccentric the insects themselves are in their appearance. A locality may be badly infested one year and free the next, and the reverse is equally true. There may be a series of bad years or a series of exempt periods; there may be only a single destructive brood a season, or the maggots may be troublesome

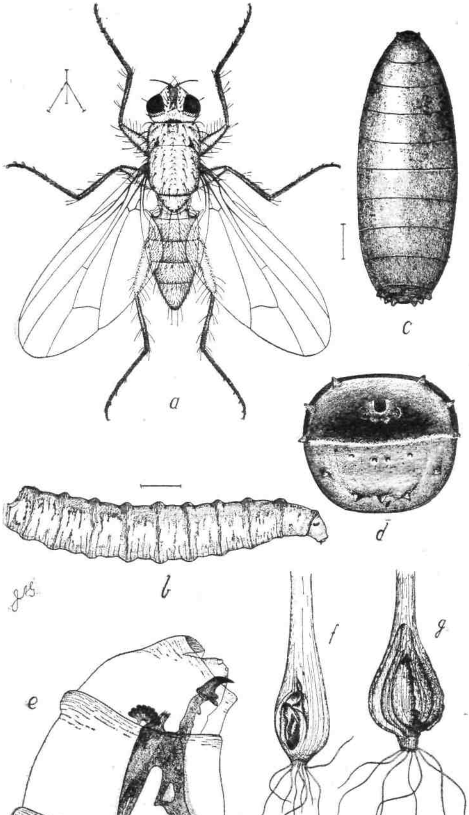


Fig. 11.

throughout the growing period. These irregularities of appearance have interfered somewhat with our judgment concerning the value of preventive application, because in some cases at least it was an open question whether exemption from attack was due to the application or to some natural cause that would have produced the same effect had no application whatever been made.

Despite these difficulties it was decided to attempt a series of field experiments on cabbage and onion maggots during the season of 1906, and to secure the co-operation of a few practical growers, materials to be furnished by the office, growers to make the applications, results to be judged by both parties.

Briefly stated the life cycle of the common root maggots is as follows: The adult flies live throughout the winter in such shelter as

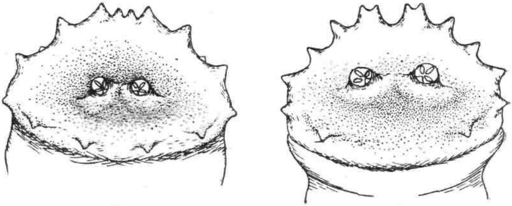


Fig. 12.
End segments of the Onion Maggot (1) and of the Cabbage Maggot (2); much enlarged. Original.

they can find about the farm. They appear in spring about the time their food plants are well started, lay their eggs on the plant as near to the surface of the soil as possible, and when these hatch, within a day or two, the young maggots begin to dig their way into the root, stem or bulb, as the case may be. Injury does not usually become noticeable until the maggots are so well advanced in growth, or so protected by being imbedded in plant tissue, that remedial measures are apt to be too late to kill the insects or to save the plants. When full grown the maggots usually move a little distance from the plant, contract and form pupal cases, and lie quietly a few days before the final change to the adult fly. There may be several destructive broods in the course of the season, or

there may be only a spring or spring and fall brood, but in every case the larval life is short, and the life of the adult extends through an unknown period.

The Materials to be Tested.

Some of the applications to be made were of well-known materials, with which contradictory results had been obtained, and some were tried simply to see how results in different hands and in diverse localities would compare.

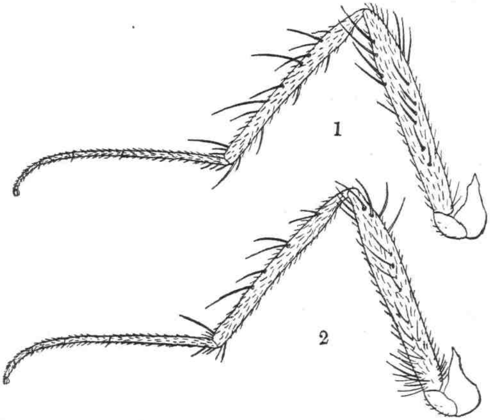


Fig. 13.
Hind leg of male Onion Fly (1) and of male Cabbage Fly (2); much enlarged. Original.

1. *Ground Tobacco:* to be dusted liberally around the plants on the surface of the ground. Is intended as a repellant, must be in place before the eggs are laid and must be renewed at short intervals until all flies have disappeared. It was also desired to learn whether the leaching from the ground tobacco would kill the young larvæ provided any hatched before the tobacco was in place.

2. *Powdered White Hellebore:* to be used like the gro tobacco as a preventive, but also as a killing agent in the form decoction of two ounces of the powder steeped in one gallon of water. Applications of the decoction at the rate of three to ounces per plant whenever maggots were actually present.

3. *Carbolic Acid Emulsion:* make into an emulsion one po hard or one quart of soft soap, one gallon of hot water and one of carbolic acid. Dilute for use with thirty parts of water. is a killing agent and was to be applied whenever maggots present on the plants.

4. *Scalecide:* a killing agent, to be used like the carbolic emulsion at the rate of one to twenty-five. This is a petrol preparation that had never been used against underground ins and it was desired to learn of its effect on them and on the pl themselves.

5. *Kerosene and Sand:* a large cupful of kerosene to a pai dry sand, well mixed and applied on the surface around the bas the plants to be protected. It is a repellant and should be position to prevent the fly from laying eggs.

6. *Kerosene Emulsion:* to be made according to the u formula of one-half pound soap, one gallon of water, two gallon kerosene. Dilute for use with twelve parts of water and appl a destructive agent whenever maggots are present on the plant

7. *Exposure:* remove the soil from the base of cabbage plant soon as they are well rooted and allow a long stem to be exp for a week so as to toughen it. Then hill up around the plant pack well. The suggestion is that if eggs are laid on the toughe stem the young larvæ will not be able to penetrate it and will Must be done before any flies are in the field.

8. *Tar paper disks:* round disks so cut as to fit around the s of a cabbage plant at the surface of the ground and intended to vent the flies from getting at the place where the eggs shoulc laid to give the resulting larvæ a fair chance for life.

The following growers agreed to use and report upon one or n of the materials above named:

Mr. Howard G. Taylor, Riverton, Burlington county.

Mr. Arthur P. Seabrook, Husted, Cumberland county.

Mr. L. H. Stemler, Matawan, Monmouth county.

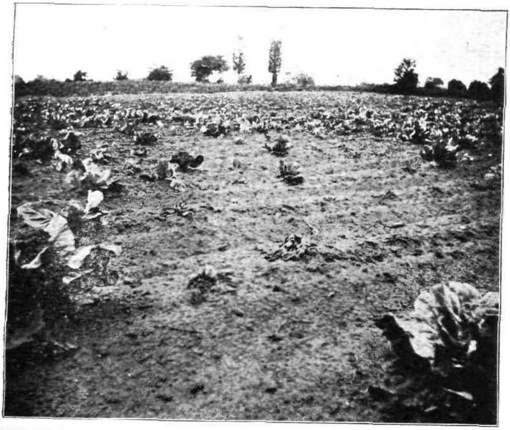
Mr. Geo. E. Woodward, Windsor, Mercer county.

Mr. E. C. Ryan, Bakersville, Atlantic county.

Mr. Edwin R. Adams, Bakersville, Atlantic county.

Fig. 14.

Riverton Experiments, May 21. At the left a view of the cabbage rows infested with maggots at the right a nearer view of the rows, with dying plants. From original photos.



Ground tobacco, powdered white hellebore, carbolic acid and scalecide were furnished to all those that used these materials. We could get no one to try the paper disks. Complaints of injury and offers to try experiments were received after the insects began to appear in the fields, but practically always so late that by the time application could be recommended and made they were too much delayed to be effective.

Mr. Dickerson was assigned to arrange for and to watch the experiments, but as it was desired to make this largely a growers' trial, all the applications were made by them and at times selected by them except as otherwise noted here. The results, while they seem at first sight disappointing, were really not so when closely studied, and they give material for practical recommendations which will be made in a bulletin on the subject. It is desired here to record only the experiments made to show the varying conditions and results.

Riverton Experiments.

April 25th, Mr. Dickerson found that Mr. Taylor had set out five rows of cabbage plants solely as subjects for this experiment. One row was to be used as a check, the others divided into one-half rows were to be used in the experiments. The first application of tobacco and hellebore was to be made on the 26th.

May 21st, maggots were found in considerable numbers on both treated and untreated rows, and at first sight the latter were no better than the former, but on search many places were found in the rows treated with carbolic acid and kerosene emulsions which showed maggot attack while the insects themselves were gone. Neither the tobacco nor the hellebore had, apparently, served as a repellant. The scalecide had injured the plants and had not, apparently, killed the insects. The carbolic acid emulsion had been used at half strength only through an unfortunate misunderstanding, not due to Mr. Taylor, and the test was not a fair one. The difficulty seemed to be largely mechanical; many of the maggots were very low down on the roots, while others seemed to be covered by an exudation that acted as a protection.

June 8th, the larvæ had very generally changed to the pupal stage and many of the flies had emerged, so that the experiments, as against that brood, might be considered closed. All the plants

were set April 30th, and each half row or experimental unit contained eighty-five plants.

No. 1. *Ground tobacco* was thoroughly dusted around the plants May 11th, 18th and 21st. On this series twenty-two plants were destroyed by the maggots. The application intended for April 26th was not made, and it is probable that this omission materially affected the result.

No. 2. *Powdered white hellebore* was used, like the tobacco, May 11th and 15th, and on May 18th and 21st it was used as a decoction—two ounces to one gallon of water, a teacupful to a plant. Seventeen plants were destroyed by the maggots. As in the previous case, something was lost by delay.

No. 3. *Carbolic acid emulsion* was used at the rate of one-half pint to twenty-five gallons, May 15th and 18th, and at the rate of one-half pint to twenty gallons May 22d. The applications were too late and too weak and thirty-eight plants in the series were destroyed by the maggots.

No. 4. *Scalecide* was used at the rate of one to twenty-five of water, May 15th, 18th and 22d. Some injury was caused to the plants, and apparently there was little or no effect as against the insects. Sixty-seven plants in this series were destroyed by the maggots or by the added injury due to the insecticide.

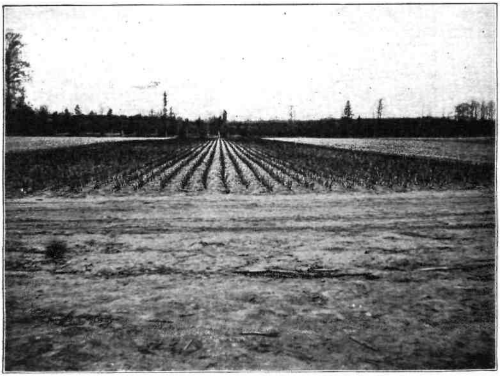
No. 5. Exposure was tried on this series, *i. e.*, the earth was removed as described in the outlined plan, but infestation was so obvious that the carbolic acid emulsion, one-half pint to twenty-five gallons, was applied May 18th and 22d. On this series thirty-seven plants were destroyed by maggots.

No. 6. *Check Row* was so generally infested May 22d that hellebore decoction, six ounces to one gallon of water, was used. Thirty-three plants on this series were destroyed.

No. 7. *Kerosene and Sand* were applied May 15th and 22d, as described in the outlined plan. On this series twenty-nine plants were destroyed.

No. 8. *Kerosene emulsion* was used at the rate of 1 to 12 of water May 15th and 18th, and at the rate of 1 to 10 May 22d. On this sixty-eight plants were reset. Oil injury was undoubtedly responsible for the death of some of these plants.

No. 9. *Check Row*, no application; forty-seven plants were destroyed.



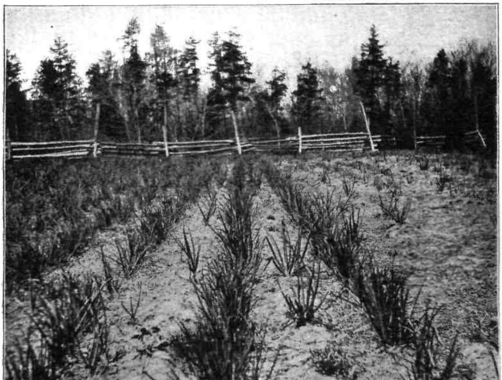


Fig. 16.

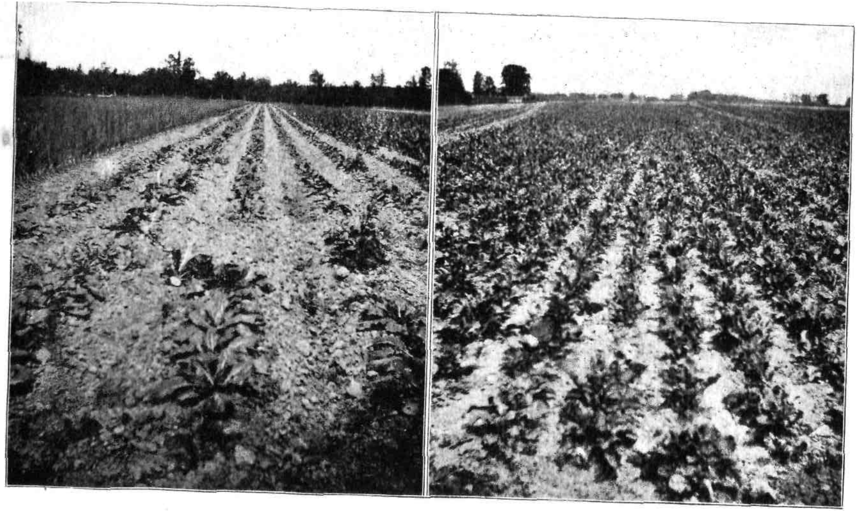


Fig. 17.

Husted Experiments, May 26. To the left, five rows of turnips so injured as to be plowed up. To the right, a bed of radishes abandoned after a few pickings. From original photos.

No. 10. *Check Row*, no application; forty-one plants were destroyed.

Expressed in tabular form, we have it as follows:

Material.	*Plants Lost.*	*Material.*	*Plants Lost.*
Tobacco	22	Check and carbolic acid	33
Hellebore	17	Kerosene and sand	29
Carbolic acid emulsion	38	Kerosene emulsion	68
Scalecide	67	Check	47
Exposure	39	Check	41

Placed in this way, the only materials for which any obvious advantage can be claimed are tobacco and hellebore. The kerosene emulsion and Scalecide make a frightfully bad showing, while the kerosene with sand stands third in the list of plants lost.

On a general inspection throughout the territory around Riverton, Mr. Dickerson found that the maggot had taken anywhere from one-third to one-half the plants on almost every plantation. Based on this general rate of infestation, only the hellebore and tobacco showed any decided benefit.

An obvious criticism is that the experimental applications were begun too late, and that none of the material had an opportunity of acting on the very young maggots, where their effectiveness might have been at the maximum. The carbolic acid emulsion was, as already stated, too weak to be of any use except against the smallest larvæ.

Husted Experiments.

April 23d, Mr. Dickerson found on the Seabrook place onions in almost all stages of growth; just germinating from seed sown a few days before; sets that had sprouted three to four inches, and "scallions" ready for sale. The field of scallions had been sown in September to be ready for March; the young plants were almost completely wiped out by maggots; new seed was sown in October, and the scallions are therefore a month late, but free from maggots. The adult onion fly was observed among these plants.

May 26th, an examination of conditions showed that the tobacco and hellebore had been used on May 8th and 15th, and the kerosene emulsion, Scalecide and carbolic acid emulsion on May 23d. Rows of onions growing for sets, and others growing from sets, were found to be quite as badly infested where treated with the ma-

terials as when untreated. The story was repeated on the turnip radish and cabbage patches, and apparently all the application were complete failures. The preventives, however, were applie too late, because the flies were already seen April 23d and the firs application was not made until May 8th. So the carbolic aci emulsion was not used at sufficient strength, nor until the insect were so well grown that many of them were protected by the con tracting skin or in the plant tissue.

June 12th, another visit was made and a very careful investi gation was made of the onion-growing practice and how the mag got affects it. It was found that the latest applications of th carbolic acid emulsion made at the proper strength had bee effective in killing the insects, though too late for much practica result, and most of the insects were then in the pupal stage o already changed to adults.

Mr. Seabrook has been one of the heaviest, if not the heaviest sufferer from maggot attack in the State, the actual money los for the season being not less than $1,000. Large areas of radishe were plowed up before even a small percentage of the crop ha been marketed, a field of turnips was totally lost, cabbages wer in nearly as bad condition and the onion crop had been seriousl diminished in value. His experience has been unfortunate fo several years past, yet it has also given a clew to what may prov to be a practical method of control, as will be developed later.

Matawan Experiments.

April 27th, Mr. Dickerson visited Mr. Stemler to arrange wit him concerning the experiments to be made against the onio maggots. Several rows had been sown that were not yet up, an on the plants up from seed sown in cold frames no signs of th flies could be found. Mr. Stemler agreed to try most of the ex periments and some of his own in addition, so it was left to hi to arrange as he chose.

May 19th the place was again visited; the plants from seed an cold frames were all in good condition, but adults were observe on the plants and on the wing. No maggots were found on searc at this time, although Mr. Stemler said he had found one in a plant earlier in the day. All the preventive materials had bee

applied according to directions, and, in addition, carbolic acid and slaked lime had been used on the older plants.

June 7th, Mr. Dickerson made a final examination and found that there had been very little feeding in the onion patches, the only sufferers being on the outside or check rows. One row was devoted to each of the experiments and the remainder of the patch was treated with the lime and carbolic acid. Mr. Stemler's place was badly infested last year (1905), and this year (1906) the infestation was so slight that it was scarcely noticeable, while neighbors on either side of him have badly infested plots. The plantations of 1906 were not far from those of 1905, so that distance could not be responsible for the exemption; besides, flies were actually observed on the onion plants May 19th. Mr. Stemler furnishes details of the applications made.

Tobacco, white hellebore, kerosene and sand, one row each; kerosene and sand was made by adding one pint of kerosene to eight quarts of sand.

First application was very freely applied just before the onions came up.

Second application was made *three* days later. This and all the following were somewhat lighter than the first application.

Third application was made *five* days after the second.

Fourth application was made *seven* days after the third.

Fifth application was made *seven* days after the fourth.

Sixth application was made *seven* days after the fifth.

Seventh application was made *seven* days after the sixth.

In each case the material was put on while the plants were wet with dew.

Scalecide, carbolic emulsion and kerosene emulsion were used as killing agents, each on one row. Scalecide was used 1 to 25; carbolic emulsion was used 1 to 50; kerosene emulsion was used 1 to 12.

First application was made just as soon as the onions were fairly up.

Second, third, fourth and fifth applications were made at intervals of seven days between each.

In the field, the first, fifth and ninth rows were left as checks, where no remedy was applied. On all other parts of the field outside of the experiment and check rows, lime and crude carbolic

acid was applied once each week for four weeks, beginning just after the plants were up.

The mixture was made by slaking lime and leaving it quite thick, using one and one-half quarts to one gallon of water and one teaspoonful of crude carbolic acid.

The Scalecide and kerosene emulsions proved injurious to the growth of the onions. The first fly was seen May 13th. The first maggots were found May 24th in the check rows, where nothing was used, and also in the row on which Scalecide was used. In the other parts of the field no maggots were found.

No fly was to be seen after the crude carbolic applications were made, and the odor of the acid was perceptible several days after each application.

Mr. Stemler claims that as the result of his observations the carbolic acid emulsion before the plants are up and the lime and carbolic acid mixture after they are up should be used to "exterminate" the onion maggot.

White hellebore and tobacco dust are also good, but should be applied very freely before the onions are up, and also every time it rains afterward.

As compared with the previous experiments, the one just recorded is remarkably successful, and it should be noted that, as compared with the others, this latter one began before the plants were actually up, and the applications were continued at intervals of a week or less for a month.

Other Experiments.

The applications at Bakersville and at Windsor were inconclusive because the maggots were so scarce that even untreated plots remained free from attack, and no basis for comparison existed.

No recommendations for actual practice are made at this time, but growers are invited to study Mr. Stemler's results based on early and frequent applications of whatever material is used.

THE PERIODICAL CICADA.

Tibicen septendecim.

Just seventeen years ago I wrote in my first Report as Entomologist to the Experiment Station: "There will be many who contend that the insect appears every few years and that the seventeen-year period is only imaginary, while others who have observed them in one locality only will ridicule the assertion that they are met with in any years but those shown on their own records." At *that time also I listed the broods known to occur in New Jersey* and gave their distribution as shown from the records.

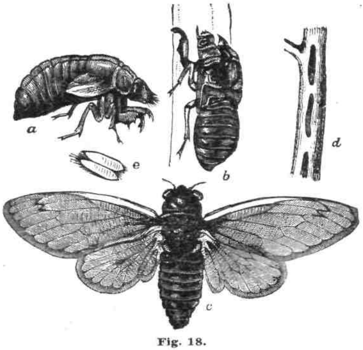


Fig. 18.

The Periodical Cicada: *a*, pupa ready to change; *b*, empty pupal shell; *c*, adult; *d*, cavities to receive eggs; *e*, eggs, enlarged.

Every brood then listed has appeared on schedule time, and in my Reports for 1894, 1898 and 1902 will be found accounts of the broods occurring in those years. Since 1889 our knowledge of this insect has increased so that instead of twenty-two broods known at that time we now record thirty, as worked out by Mr. Marlatt in circular 45, second series of the Entomological Division, United States Department of Agriculture.

Brood No. VIII. in my Report for 1889 is now No. XIV. of Marlatt, and its distribution was given as "the southeastern part of Massachusetts, across Long Island, along the Atlantic coast to Chesapeake bay, and up the Susquehanna at least as far as Carlisle, in Pennsylvania; also in Kentucky, at Kanawah in West Virginia, and Gallipolis, Ohio, on the Ohio river." No definite localities were then known in New Jersey, but as the results of my investigations, four points were established: Englewood, Bergen county, along the Palisades; Princeton, Mercer county; Palmyra, Burlington county, and Red Bank, in Gloucester county. This makes a diagonal but disconnected line across the State, and nowhere did the insects occur in any numbers.

My experience with the more recent broods and the observations made of the deadly warfare waged by the sparrows on these insects inclined me to the belief that the brood would appear in greatly reduced numbers during the current year, if at all, and I therefore asked a large number of the office correspondents to keep a lookout for the species, and to send in reports and specimens should any occur in their locality. The members of the Brooklyn, New York, Newark and Philadelphia Entomological Societies were also asked to co-operate, and the office staff was charged to observe any signs of the insects' presence and to question farmers everywhere.

The result was entirely negative; not a single specimen was received from any locality within the State; not a sign of their presence was noted, and all reports of their occurrence when investigated proved to be unfounded. This brood seems to have been completely eliminated, or so greatly reduced in numbers that nothing was seen of it. On Long Island and in Pennsylvania the insects appeared in their usual numbers, and I believe that in other parts of their range they were also observed. On Staten Island a few pupa shells were found, indicating that the insect did appear there.

Mr. Dickerson, in the course of his inspections of orchards and nurseries, covered the entire ground of its appearance in 1889 and made special trips to Englewood and to the woodland area between Princeton and Rocky Hill during the period of their usual occurrence. Nowhere did he find any trace of the species.

It is more than probable that the remaining broods will become less numerous at each appearance as the forests are cleared and as

the sparrow domination increases, but it will be many years before this interesting species disappears from our fauna. Its absence this year was not unexpected, because in 1902 I wrote: "The brood is a small one, the area of its appearance is limited in well-settled regions, and it is doubtful whether in 1906 it will be noticed at all."

SHADE TREE INSECTS.

Attention has been called to the fact that increased interest has been and is now being manifested in city shade trees, and that Bulletin No. 181, dealing with the insect enemies of such trees, has been in constant demand, until now very few copies remain. The municipalities that began work in the recent past have continued their operations and have increased them in extent, while others have either begun work or have manifested a desire to do so. In a greater number of cases individuals or bodies of individuals have taken up the matter in smaller cities, towns and villages, and in all cases where applications were made to the office prompt attention was given and such recommendations were made as seemed to be demanded. In every instance it was made clear that it was the desire of the office to co-operate to the extent of its ability.

Newark.

The most complete organization for the care of shade trees exists at Newark, where the work is in the hands of a shade tree commission with large powers and a liberal appropriation.

April 13th, Mr. Dickerson went over the city, in a general way, with Mr. Carl Bannwart, the secretary of the commission, who is in general charge of the field work. It was found that as to the cottony maple scale the prospects were that it would be present in much smaller numbers than in 1905, although locally there were trees as badly infested as at the same period last year. This was offset by other localities in which the natural enemies had made an almost clean sweep, and almost everywhere conditions were much improved.

Oyster-shell scales were present in numbers on some poplars and other trees, and an *Aspidiotus* on maples was obvious in some places.

July 11th, after the heavy windstorm of the day before, Mr. Dickerson again went over the ground with Mr. Bannwart and examined more particularly the broken branches and limbs that everywhere testified to the force of the wind. The work of the wood leopard moth was in evidence everywhere, and particularly on elms and soft maples, the weakening of the branches caused by their borings being responsible for a large proportion of the breakage.

As to general insecticide work, the spraying was done with a combination of arsenate of lead and Bordeaux mixture at the rate of ten pounds in one hundred gallons of water, and that did not seem strong enough to kill the nearly mature caterpillars of the tussock moth, though it did appear to make them sick and to hasten their descent from the trees. This and the elm-leaf beetle have been the most troublesome species, though the beetle was not as abundant as it was at New Brunswick. The insects have been kept in check pretty well, however, in the parks and on the main streets, but on some of the side streets here and there were a few bad trees, because it was simply impossible to get everywhere in time.

October 20th, Mr. Bannwart wrote me, in response to my request, a summary of what had been done, which is as follows, omitting some irrelevant details:

The most troublesome pests which afflicted our young elms were the elm beetles. Our spraying during the first of the season was very successful, but in two subsequent sprayings we did a great deal of harm. As soon as I found, after the men had worked two days, that the leaves were being injured, I stopped the spraying with that insecticide; but most of the elms had been gone over in that time and a great many of them had lost their leaves. We, of course, do not want to give up to the elm-leaf beetle. We expect to spray early in the season next spring with a hope of killing the adults. I have not noticed any great injury resulting from their work on the large elms.

The insects second in importance were the tussock moth caterpillars. We protected the park trees against them absolutely. The work on the street trees was at least 75 per cent. better than last year, and there were no small trees defoliated by them. We creosoted the egg-masses preparatory to the second brood, and

found this absolutely effective. In the spraying we used arsenate of lead almost exclusively. In the first part of the season used the Bordeaux mixture with the arsenate of lead, using about ten pounds of the latter and eight pounds of the former in paste form, with lime, to one hundred gallons. There seemed to be a tendency for one mixture to neutralize the other —at least in color—so that we could not see the mixture on the leaves.

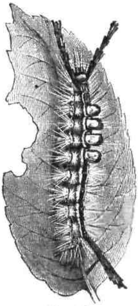


Fig. 20.
Caterpillar of Tussock Moth. After Riley.

The tussock moths were more numerous than usual, but our spraying operations have been in proportion to their increase, and the campaign showed that their rise and fall were absolutely in our control. This confidence is emphasized by the additional ability to fight them in the egg and pupa stage.

On the whole, the spraying operations were satisfactory in connection with the tussock moth caterpillar and not satisfactory in spraying for the elm-leaf beetle. This may be because the elm beetles were more noticeable on the younger trees and the leaves were more tender.

It may be well to say in this connection that in purchasing insecticides for the use of the commission, the desire to give local competitors an opportunity to supply part of the outfit resulted in obtaining a lot of imperfectly-prepared material with a large percentage of free arsenic. It is not likely that this mistake will be repeated. That the elm beetle is not in itself so difficult to keep in check is proved by our experience at New Brunswick, where it was much more plentiful than in Newark, and a record of this experience finds a fitting place here.

The Elm-Leaf Beetle.

This insect, after a series of years during which little was seen of it in New Brunswick, recovered its ground during the season of 1905, which was favorable to it, and great numbers of the adults went into hibernating quarters in good condition. This fact noted led to the belief that it might prove injurious in 1906, and preparations were made for spraying the trees on the college campus in

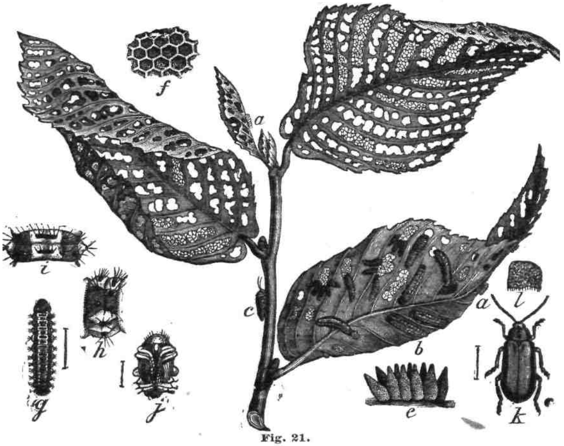


Fig. 21.

Elm-leaf Beetle: *a*, *a*, patches of eggs on leaves; *b*, larvæ feeding; *c*, adult; all natural size; *e*, egg mass; *f*, surface of egg; *g*, larva; *h*, *i*, larval details; *j*, pupa; *k*, beetle; *l*, surface of elytra; all enlarged. From Rept. Ent., U. S. Dept. Agl.

the spring of 1906. With the unfolding of the leaves the beetles appeared in numbers, and as soon as the first egg clusters appeared the trees were thoroughly sprayed with arsenate of lead at the rate of about five pounds in one hundred gallons of water. The object was to kill off as many of the adults as possible before they had a chance to oviposit, and this was very largely accomplished. On some favorite trees, however, so many egg clusters were found that

it was deemed wise to re-spray them as soon as the first larvæ were noticed.

The result was all that could be reasonably desired. A large proportion of the trees were practically unharmed, while none were sufficiently injured to cause a dropping of leaves or any marked disfiguring. This was in strong contrast to other elms in the vicinity, which were completely defoliated before midsummer and did not become recovered until fall, when a second crop of foliage was made.

Three different makes of arsenate of lead were used, ranging in price from thirteen cents to eighteen cents per pound, and so far as results were concerned, no difference was noted. In no case was there any burning of foliage, no matter how excessive the application, and in all cases the foliage was protected during the entire season.

The object of the record was not so much to determine the killing power of the poison, for that has been sufficiently demonstrated, as to show that practically large trees on a limited area could be completely protected while unsprayed trees around about were badly injured. It was further intended to show that even a single spraying might be sufficient to protect, provided the application was made early enough, or before eggs were deposited. It is probable that it was not really necessary to spray a second time even those trees on which egg clusters were present in numbers, but as there had been a day of rain just after these trees were first sprayed, it was deemed wiser to take no risks.

East Orange.

This city also has a shade tree commission as complete in its organization as that of Newark, and second to it only in the extent of its operations. The secretary and superintendent of this commission is Mr. William Solotaroff, and he has handled a somewhat different problem equally well. At my request he has furnished a summary of the work of the season of 1906, as follows:

"The insect that gave us the most concern this year and last was the *Pseudococcus aceris* on the sugar maple. In 1905 it was a pest here of the worst form. On August 1st, 1905, we sprayed the trunks and main limbs of some of the trees, and I found that the

larvæ and the adults were killed, but that the cocoons, in which state the insects largely were, were not penetrated. On August 23d began the treatment of the sugar maples by dry brushing. One man with a house broom cleaned the trunk to a height of about eight feet; another man with a bristle brush, fastened to a twelve-foot pole, cleaned to a height of about fifteen feet, and a third man with a hand brush and ladder cleaned the rest of the tree. By this means every sugar maple in East Orange was brushed. Some larvæ escaped, and I waited until the leaves fell and the larvæ of the last brood took to the trunks, and then I sprayed the trunks and main limbs of the trees on several trees with Kill-O-Scale. During the winter the trees showed little trace of larvæ, but this spring I noticed that some of the trees were covered with a few larvæ again. On August 6th of this year we began washing the trunks of the sugar maples that showed some scale with Kill-O-Scale, 1 to 20, and treated the trees on about half a dozen streets that had a predominance of sugar maples. The result has been that almost no females were found on the leaves in the latter part of the summer and no leaves fell, as had been the case of the year before. The trees are clean now."

"The cottony maple scale I found was present in very small numbers. The trees that were treated by means of the solid jet of water to break up the egg clusters in 1905, as explained to you before, showed almost no adult females when examined this spring. Some trees on other streets showed the insects more numerous, but not in sufficiently large numbers to make it necessary to do any fighting against them.

"The tussock moth was present in very small numbers. The two pickings of egg clusters of the two broods in 1905 seemed to have cleaned them. On June 13th began spraying with arsenate of lead some linden trees that we had set out in the eastern section of the city and collected egg-masses on some larger trees in that part of the town. There was no appearance of the second brood in any way to call for work against them.

"The elm leaf beetle was present in a general way all over the city, but not as a very bad pest, excepting on some trees here and there. On July 9th began to spray the elms on a few streets with arsenate of lead. Of course, there was not much that could be done at that time, as the insects were near the time of pupation, and all the damage had been already done.

"The fall web-worm and the bag-worm were present in some numbers, especially the web-worm. The latter was especially numerous on the wild cherry and in gardens on fruit trees. The only combating of the web-worm that came under our charge was on a street of Oriental planes that we had planted. We cut out the twigs that were infested and burned them."

Montclair.

Montclair has no organized shade tree commission, and the task of keeping the trees in condition is imposed upon Mr. Malcolm H. Smith, superintendent of roads and sewers. This task is really very well performed, all things considered, and Mr. Smith keeps in communication with the office, while occasional inspections are made by one or the other member of the office force.

June 28th, Mr. Dickerson, at the request of a committee of the council appointed to investigate the condition of the shade trees, made a rather careful survey, accompanied by the members of the committee, and later presented a full report showing what was observed and making suggestions as to what could and should be done to keep the town trees in health and vigor and free from insect pests.

August 20th, he made another visit, at the request of the superintendent, and found a local infestation of the pigeon *Tremex* on red maples, as well as some injury due to bark beetles.

At those places where the cottony scale was so very abundant last year and the year before only isolated examples could be found, and not many of those. Everywhere the work of the *Coccinellid* was in evidence, and very few survivors remain to continue the species. The *Pseudococcus* was almost equally well in control, and occurred nowhere in obvious numbers. On the whole, conditions were favorable, and the trees generally were in good shape, so far as insect infestation is concerned.

Hoboken.

This city also lacks organization for keeping its trees in good condition, but the council did go far enough to employ Messrs. Bobbink and Atkins, of Rutherford, who give essentially the following account of their doings:

We sprayed the trees in the parks in the city of Hoboken principally for the tussock moth caterpillar. The remedy that we used was arsenate of lead, and the results were more than satisfactory. We used a Field force pump with a one-hundred-and-fifty-gallon tank, and about eight pounds of the arsenate to the one hundred and fifty gallons, though we believe that a less amount would be quite efficacious. We do not believe there is another city in the United States, and we say this without reserve, where the trees are in such a deplorable condition as in the city of Hoboken. It is quite an easy matter to pull off large cakes of the tussock moth cocoons and eggs a foot square. We only gave the trees one application at just about the time the caterpillars were commencing to feed, and we strongly urged the council to give us an opportunity to give the trees a second application when the second batch of caterpillars appeared, but unfortunately they allowed this to go by default.

For San José scale we have used "Scalecide" to splendid advantage; in fact, it is the best thing we have discovered up to date. We have also used "Horicum" with equally good results.

In treating the trees of the town of Rutherford we sprayed principally for sucking insects, and used an application of whale oil soap, with a small proportion of tobacco juice added. We were quite pleased with the results of this application.

We find that there is now being quite an interest manifested in the preservation of the trees in most towns, and we believe this is brought about through the efforts of the Experimental Station and the shade tree commissions.

We have worked on the basis of $25 per day for our outfit, but there is little profit in it at that rate, and we propose to increase our charges to from $30 to $35, according to the caliber of the trees which we may have to treat. We believe that orchard spraying can be done for as low as $10 to $12 per day, and where a farmer owns the machine for a good deal less.

Rahway.

Rahway has no organization for shade tree work as yet, but at the request of the street commission, Mr. Dickerson made an examination of their shade trees in March and reported upon the

conditions found. The city trees are largely silver and soft maples, and last year the cottony scale was exceedingly abundant. At the time of the inspection the remnants of last year's adults were still in evidence, and among them were a number of hibernating, living examples. There was evidence that the *Coccinellid* had been at work, and it was believed that it would be safe to predict the control of the pest within a year or two at most.

Other Towns.

No systematic record was kept of places where assistance or information was given by correspondence only, but there were a number of them, and largely from the coast towns, where much tree planting is now done.

In *Jersey City* an inspection was made September 6th at the request of a property-holder and it was found that a series of small, recently-set trees were dying off—maple, poplar, plane, etc. These had all been banded about five feet above ground with tar, and cotton tied over this. The banding was only a few inches wide, and was done in the spring of 1905. The trees began dying only a few weeks previous to the inspection, and this was due to the tar band. This, according to Mr. Dickerson, acted in two ways: First, the tar hardened and prevented the expansion and increase of the bark and tissue, and second, the tar had apparently penetrated the bark and underlying tissue and killed it. This was fully borne out by the examinations made, and removal was advised, although the trunks were alive below the girdling and some new shoots were being made.

At *Morristown,* inspections were made by Mr. Dickerson June 5th and July 14th, at the requests of individuals whose trees were showing signs of injury, and advice was given in both cases. In the one instance sugar maples that were badly infested with the *Pseudococcus* had been painted with undiluted crude petroleum, and these were dying, and later died. There is no doubt that the oil killed them, although it tested forty-four degrees, as shown by samples received at the laboratory, and although other trees of similar varieties and age had been safely treated in previous years.

At *Mountainside* the "Union County Tree-Spraying Company" has established itself and is doing considerable work in the neighboring towns, villages and their gardens and streets. It has a neat tag which is attached to each sprayed tree, giving date of application and material used.

Altogether, this branch of the work of the office has not been neglected and has been of distinct importance.

THE SIGNATE LADY-BIRD BEETLE.

In those cities in which the cottony maple scale or *Pulvinaria* was most abundant during 1905, it was noted that the natural enemies were also increasing in proportionate numbers, and it was predicted that during 1906 the infestation would be much less, if not entirely cleaned up. The most important agent in this work was without doubt the signate lady-bird beetle, *Hyperaspis signata*, which was figured and described in the report for 1905. In order to follow its work and its relation to the host, Mr. Dickerson was instructed to watch it on his visits to the infested cities and towns and in New Brunswick, which he did.

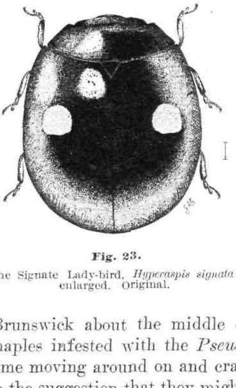


Fig. 23.
The Signate Lady-bird, *Hyperaspis signata*; enlarged. Original.

It was first seen in New Brunswick about the middle of April, on the trunks of sugar maples infested with the *Pseudococcus*. The latter were at that time moving around on and crawling up the trunk, and this leads to the suggestion that they might be destroyed in large numbers by winter spraying with a soluble oil, supplemented in early spring by a sticky band, say of "tanglefoot," at the base of the branching, which would prevent the infestation of the tree above.

The beetles, when observed, were probably fresh from their winter quarters and resting quietly on the bark, and some examples, with a number of the *Pseudococcus*, were taken to the labo-

tory. Next day these were observed feeding on the *Pseudococcus* the same way that other specimens had been observed feeding the larva of *Pulvinaria* in 1905. pril 26th, and on several succeedg days, more beetles were seen the infested trees, but after ay 4th they disappeared and re not again seen.

On trees infested by *Pulvinaria* beetles were seen in New Brunsick, but no very close examinans were made, and as the insted branches were well out of ach and the lady-birds are very tive they might very easily have en, and probably were, present. On May 8th the lady-birds were served both at East Orange and ontclair, but not in large numrs. In East Orange the work the shade tree commission, in ne places, and the work of the etle, in others, had reduced the *ilvinaria* to harmless numbers, d in Montclair the beetle, supmented by the little parasitic *ccophagus,* had wiped it out nost altogether. In all the loities where examinations were ide the beetle had done good rk against the soft scale.

In 1905 the beetle was but ely observed on trees infested th *Pseudococcus,* but during present year it was observed erever this scale was seen, and ten the larva was found imdded in the cottony mass of the ult female, where it was as ll concealed as in the *Pulvinaria,* but the pupæ were not so well otected and undoubtedly occurred on the undersides of the

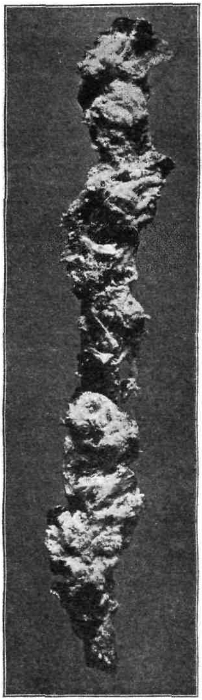


Fig. 24.

Twig with cottony scales torn and eaten by the Signate Lady-bird; slightly enlarged. Original.

July 5th, the lady-bird was observed feeding on the tulip soft scale, *Lecanium tulipiferae,* near Summit. Several badly infested trees were found and on all of them the adult beetles as well as larvæ were present. In this case there was no protection for any stage and the pupæ were found on the undersides of the leaves or resting in and partly concealed by the rough bark.

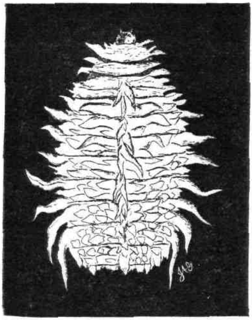


Fig. 25.
Larva of Signate Lady-bird; much enlarged. Original.

The beetle larvæ undoubtedly destroyed many of the scale larvæ, but were actually observed feeding only on adults. In this case they did not get within or under the scale, but rested at its side, and apparently sucked out the body juices through a puncture. A similar method of feeding was observed in an allied larva later in the season. This was feeding on plant lice, and was seen to hold on by a leg which had been punctured, while under a lens the body juices of the louse could be seen running down and passing into the mouth cavity of the larva. Small scale larvæ may be eaten entire by the larva of the *Hyperaspis,* but of large specimens only the juices are absorbed.

The interesting point in these observations is that whereas in 1905 the lady-bird beetle and its larva were found feeding almost exclusively on the cottony scale, *Pulvinaria,* in 1906, when the latter was absent or rare, the *Pseudococcus,* and even the *Lecanium,* were attacked and used as substitutes. The *Pulvinaria* is undoubtedly the normal food, and it will be interesting to observe whether in its practical absence the beetle will maintain its numbers on the other scales, of which the tulip soft scale at least is troublesome enough to need an effective check.

SAN JOSE SCALE.

This insect continues to demand a very large share of attention, but while it is still dreaded, it is no longer the terror and potential barrier to fruit culture that it was for a time considered. There is no doubt that thousands of trees have been killed and that thousands of trees will yet die from its attacks, but it is equally true that many of these thousands of trees died as much from neglect as from scale attack, and that other infested thousands will die in the same way. During the past year Mr. Dickerson and myself have visited every orchard-growing district in the State, and in one month I used one thousand miles of Pennsylvania mileage alone, largely in orchard work. We have seen every nursery and nurseryman in the State, and are in position to speak from personal experience concerning orchard conditions. It is my deliberate opinion that no more trees will be lost from injuries caused by the pernicious scale, provided the owner actively wishes to keep his trees. But the man who desires to plant trees and thereafter harvest crops without further effort will find the San José scale a frightful pest, and he will continue to rail bitterly at the entomologist who fails to provide him with a remedy that costs little or nothing and requires no effort to apply. It means work and intelligence and intelligent work to avoid injury, and the man who works most intelligently will succeed best as a fruit grower. It is

Fig. 26.

Section of branch infested by the pernicious scale; *much enlarged. From Bulletin Virginia Station.*

a pleasure to be able to say that a large percentage of all the active orchardists in New Jersey come up to the standard required by scale conditions, and a matter of regret that some orchards yet remain to men who lack either disposition or ability to care for them.

Mr. Dickerson, as the result of the orchard inspection work done by him as assistant to the State Entomologist, writes: "On the whole, the orchards are in much better condition, so far as the scale is concerned, than they were a few years ago, and I believe they will continue to improve. The majority of the growers who have any number of good bearing trees are spraying, and it is safe to say that few, if any, are setting out trees without the knowledge that they will have to deal with the scale—a point in which they are materially helped by the fact that the trees which go to them from the nurseries are generally clean. Many of the neglected orchards have died and have been removed, so while there are some here and there, they are not so prominent as they were a few years ago. This is well illustrated by conditions in one of the peach districts of Hunterdon county, perhaps the leading peach-growing section of the State. The orchards throughout this region became more or less infested; the growers at that time knew little about the scale; they did not believe the stories told of it, or believed it could not be controlled, and spraying was done in many cases tardily and ineffectively, or not at all. The result was that many of the trees were lost, and a few years ago dead orchards could be seen scattered throughout the region. Last summer in driving through this vicinity I observed few dead and dying trees. I found most of the orchards, many of which have been sprayed with lime, sulphur and salt, in very clean condition, and there are some fine young orchards coming on. Most of the growers are doing what they can to keep the scale in check, and there is an increasing feeling that those who do not should be compelled to do so.

There seems to be also a feeling that the scale is disappearing and reports have come that it is not so prevalent this year as last. It is true that for some reason varieties which are usually much infested are occasionally uninfested even among badly infested trees, and it may be that local weather conditions may have aided slightly in keeping the insect in check. It may be also that this feeling is due to the fact that most of the good trees are being cared

for, while the neglected ones are disappearing, so that as a matter of fact the actual numbers of the insect are smaller.

For the most part spraying has been done in the spring, and the effort is made, apparently, to spray late—say, during March or April. It is generally known that fall spraying with whale oil soap will kill fruit buds, and several have claimed that they injured tender growth on peach with the lime, salt and sulphur, if applied before the wood is fully mature. Moreover, it seems to be generally believed that where applied thoroughly in spring, the lime wash remains for a long time, forming a coat that prevents scale larvæ from setting in such places. This and the probability that the fungicidal effect is greater when applied in spring, form additional reasons for making the application at that time.

Yet I found numerous places where Scalecide had been applied in fall, and without apparent detrimental effect on the trees. This fall work is due largely to the recommendations in the Station Bulletin, which suggests that applications made at that time would be of greater effect because the insects are not so fully dormant.

Mr. Dickerson further notes a tendency to spray more than once, and says the above materials (lime-sulphur washes and soluble oil) have also been in some instances applied twice in one season, *i. e.*, once in the fall and again in the spring. There is a tendency to do this where the trees are badly infested, for it is realized that even with the best materials it is often difficult to clean a badly infested tree with a single application. In like manner, some orchardists have used different materials the same season; one in fall, the other in spring. He cites one of the leading orchardists of the State as an example and I wrote him directly on the subject. This gentleman has probably a greater number of fruit trees under his control than any other one man in the State, and his experience with the San José scale dates back almost to the time of its first appearance within our boundaries. He has used almost every material that has ever been suggested as valuable and has spraying outfits in as great a variety as are to be found in New Jersey. He is also growing more and better fruits than ever before and is setting out new orchards yearly. His reply, under date of November 8th, is as follows:

"Thee asks just what is responsible for my good results with the scale. My theory was this: The lime and sulphur works slowly—is not apt to kill all the scales on the terminal buds—

and after using it one is apt to have scaly fruit. The soluble oi works quickly—kills the top layers of scale, and in fact all the scale it hits. But it does its work and the first rain washes it off and if one scale in one hundred is left, conditions are just righ for it to multiply and take possession of the tree. So I conceived the idea of using, first, the Scalecide to destroy 99 per cent., and then the lime and sulphur to kill and check the 1 per cent., but I confess I was not prepared to see such wonderful success. Neithei the Scalecide alone nor the lime and sulphur alone compared in satisfaction with the two together. What I wonder is, whethei two applications of either agent would have been as effectual as the combination. I suspect not."

Mr. Dickerson's report answers the question in part. After referring to the above orchards and their condition when he saw them in midsummer, he adds: In like manner I examined large, bearing apple trees which had been sprayed twice with lime, salt and sulphur. They had been very scaly, but now, late in summer, were very clean. The same conditions existed and the same results were obtained with Scalecide. I find many growers willing to make two sprayings and who feel that it is necessary, especially where trees are badly infested or are very large. In all such cases I believe that two sprayings are advisable.

A peculiarity to be noticed in excursions through the fruit-growing sections is that while in one place the mineral oil is almost universally used in some form, in others some lime and sulphur combination is the favorite. Mr. Dickerson refers to this and gives a partial explanation: "The material used in a particular locality depends largely upon local conditions. In several places I found that some good, energetic man had taken the initiative, sprayed his trees thoroughly with some particular mixture and obtained good results. This had been an example to others in the community, who did similar spraying with more or less success, and so it came about that that particular material came to be used in that locality. The character of the mixtures, also, have largely to do with their use. The various oil sprays, for examples, are easy to prepare and apply; they spray nicely and cover well, and have no irritating effect upon the skin. For these reasons I find that many prefer to use them rather than the more troublesome lime, sulphur and salt wash, even though they have to do more spraying, and in some cases even though they had to spray twice."

Mr. Dickerson might have added that much also depended upon the position taken by the agricultural paper which was locally the favorite.

With the realization of the necessity for thorough work comes a modification of practice in other respects. In the case of large apple trees, especially, it is difficult to reach the higher branches with the spraying outfit possessed by the average farmer. As a result these branches have been cut back in some instances, the owner feeling that he would rather do this and spray the rest of the tree thoroughly than to leave the top poorly sprayed and more or less infested with live scales. Another tendency in the case of badly infested trees is to cut back severely and to treat what remains very thoroughly.

And this leads to a consideration of the outfits used. In the majority of cases it is a barrel pump with one or two leads of hose, and extension poles carrying one, two or three nozzles. The Mistry or Vermorel type is generally preferred to the Seneca or Bordeaux type, the former being almost exclusively used by those who prefer the oil sprays. There are quite a number of power sprayers, however, of one kind or another. The "Niagara" is well represented and has the advantage of being very easy to operate, giving plenty of power and a great uniformity of pressure. Most of those using it seem to feel satisfied, but some consider that the price of the gas makes it too expensive. Other growers are using gasoline engines, and where there are large trees, or a sufficient number of them, such an outfit seems advisable, and has the advantage of furnishing power for other farm purposes. As a matter of fact, there are several instances where engines of greater power than was actually needed for spraying were purchased that they might be utilized in other ways. There are a few geared machines in use, and these serve well enough for medium-sized or small trees set apart, but where large trees are to be treated, or much spraying is to be done from one point without driving, it is not altogether satisfactory, and the auxiliary hand pump which usually accompanies such an outfit must be brought into play.

Mr. Dickerson says further, as a conclusion, that it will be seen from what has been observed that good results have been obtained and failures made with each of the mixtures. In considering these results and comparing the mixtures, all the factors must be taken

into consideration, and in the case of the oils the actual amount of raw material used, *i. e.*, the oil, should be the basis of comparison. For example, one man may spray with a mixture containing 20 per cent. of oil and another may use one containing 15 per cent. only, and yet the man who uses the weaker mixture may get more actual oil on his trees in a drench than the other may get with a more sparing use, each giving a complete covering to the tree.

Conclusions and Recommendations.

It is a fair conclusion, from what has been said above and from the observations recorded under the insecticide headings, that any well-made lime and sulphur combination, with or without salt, and any of the well-tested soluble petroleums, will kill all the scales that are actually reached or covered by them. It is further apparent that no one application can be relied upon to do entirely satisfactory work, and that the reason for that is mechanical rather than lack of efficiency in the insecticide. None of the materials or mixtures, undiluted crude oil excepted, will penetrate through a dense mass of scales or into all crevices so as to reach all the insects on a badly-infested tree, and none of them kill unless they come into actual contact with the insects. The soluble oils, at 1 to 20, contain so small a percentage of actual oil that a very thorough application is necessary to reach all the insects with enough to be entirely effective.

The insecticides at our command are sufficient to control the scale, and the remaining part of the problem is the mechanical one of placing them where they can get a chance to act.

Based upon all the observations and upon these conclusions, peach growers are advised to use the lime and sulphur combinations, because they have a fungicidal effect as well, and because they seem to act as a general tonic to such trees. Where the trees are only a little infested, either a fall or a spring application may be made. A fall application will be somewhat more reliable to obtain the greatest insecticide effect; the spring application seems to give better results against troubles due to parasitic plant diseases. Badly-infested trees should be sprayed twice.

Apples and pears are better sprayed both fall and spring, whatever the mixture used, and on apples I would recommend the solu-

ble oil in preference. Pear trees, unless very badly infested (and the same is true of plums), will do very well with the lime and sulphur combinations, but pear trees seem on the whole to derive as great a tonic effect from the oil as the peaches do from the lime and sulphur, and therefore I advise the former if only one kind of material is to be used. Apples should have at least one spraying with oil to reach the scales near the tips, which are so guarded that they stand more than an even chance of escape from even two applications of the lime and sulphur washes, and if one kind of material only is to be used, I advise the oil.

No oil combination that contains less than 4 per cent. of actual petroleum in the spraying mixture can be depended upon, and upon that basis "Scalecide," "Kill-O-Scale" and similar combinations, which are really liquid petroleum soaps, should be used at the rate of 1 to 15 as a minimum strength. Those mixtures that are said to be emulsions, and for which a greater percentage of actual oil is claimed, should be used at a similar dilution, even though this may give a slightly greater percentage of oil, because, for some reason which is obscure to me, emulsions are not so effective as the "soluble" oils. The K.-L., properly made and applied, is equal in effect to the soluble oils when it contains 15 per cent. of actual oil, and the same is true of the mechanical mixtures of oil and water.

The lime washes cannot be satisfactorily used on trees that have been treated with undiluted crude oil or with a mechanical mixture containing a large percentage of crude oil, because the vaseline remnant on the surface prevents a proper adhesion; but they may be used after the soluble oils because these contain no vaseline remnants, and wash off or evaporate completely.

Rain within twenty-four hours after spraying is apt to interfere with the effect of any mixture except undiluted crude oil, but the lime and sulphur combinations rarely suffer much after they are once set.

Thoroughness of application is essential whatever is used, and there should always be force enough to drive the spray into every crevice and through the hairy covering of twigs, and this is especially true of the lime washes, which tend to form a coating over a crevice or depression, instead of penetrating into it.

INSECTICIDES.

Arsenate of Lead.

This material is meeting with increased favor each year because it may be safely used on so many plants on which no other arsenical preparations can be applied, and because of its adhesive qualities.

As originally proposed it was formed by dissolving arsenate of soda (four ounces) and acetate (sugar) of lead (eleven ounces), and combining the solutions. Both of these materials are readily soluble in water and when they were combined a very fine white precipitate was formed, which sank slowly to the bottom. This precipitate was the arsenate of lead. It was not necessary to wait for precipitation, but, when the dissolved materials were united, the combined mixture was poured into the spraying tank, with as much water as was recommended for the particular insect against which it was required.

A simpler way was to put the materials in the proper proportions directly into the spraying tank with as much water as was to be used, and then stir until all crystals were dissolved and everything was thoroughly mixed.

Very good results were obtained in this way, but various practical difficulties arose—the chemicals were not always of good quality, and the resulting mixture was not a proper combination; the prices varied and the farmer often paid altogether too much for his insecticide; and lastly, the work of mixing in proper proportion was too much for many of those who would otherwise have used it.

The result was that the manufacturers of commercial insecticides took the matter in hand and there are now on the market a number of different brands, made by as many different firms, but very different in appearance, consistency and price.

In the municipalities in which spraying work has been done, arsenate of lead is quite generally adopted because there is little or no danger of injuring foliage through the carelessness of the ignorant help that must be largely employed, and some of these municipalities, in advertising for bids, received widely divergent offers and some very questionable material. It became necessary this spring to spray the elms of the College Campus to prevent injury from the elm-leaf beetle, and in order to test some of the

leading brands side by side I ordered some sixty pounds from the Adler Color and Chemical Company, of New York (Eagle brand); fifty pounds from the American Horticultural Distributing Company, of West Virginia (Target brand), and fifty pounds from the Bowker Insecticide Company, of Boston, Mass. (Disparene). I paid for the Eagle brand twelve cents per pound (in one-pound cans), for the Target brand twenty cents per pound (in two-pound cans), and for the Disparene twenty-four cents per pound (in two-pound cans). The Eagle brand cans were uniformly overweight, the Disparene was almost exactly correct and the Target brand was uniformly underweight. The Eagle brand was a dry paste, while the other two were sloppy in consistency. This does not, however, mean more water, but the addition of glucose or some other product to increase adhesive qualities. All of these materials, be it said here, gave equally satisfactory results when sprayed at the strength of approximately five pounds to one hundred gallons of water.

During the summer Mr. Carl Bannwart, secretary of the Newark Shade Tree Commission, and in charge of the spraying work, had some difficulty with the material used by him, and sent in two samples for analysis, stating that he had no sort of guide as to the amount of arsenic actually present in the material, and could not, therefore, use it intelligently. One of these was supposed to be a straight arsenate of lead (Cooper sample); the other was a combination supposed to contain copper and to be a combined insecticide and fungicide.

I handed samples of all of these materials to the chemical department, including also a new product just sent in for trial, and received the following report from Mr. J. P. Street, Chemist to the Station:

Analysis of Arsenate of Lead.

Manufacturer.	*Water.*	*Arsenic Oxid.*
Adler	51.59	14.74
Cooper	41.65	13.10
Schoonmaker (with Bordeaux)	23.97	5.58
Bowker	41.50	15.34
Target Brand	57.62	12.14
Vreeland	44.67	20.12

No attempt was made to do more than determine, first, the actual amount of water in the sample, and second, the actual amount of arsenic oxid ($As_2 0_5$).

The Schoonmaker combination may be excluded from the comparison because it is not a straight arsenate of lead, but when used as an insecticide it should have at least twice the weight ordinarily recommended to obtain the desired effect. The water in this material is less in quantity than in any other of those tested.

Of the rest, the Target brand contains more water and less arsenic than any other sample, besides being short weight, hence gives less value for the price charged. The Disparene, which is most nearly comparable with it in consistency and actual composition, is full weight and has less water with more arsenic than any except the Vreeland sample. The Eagle brand, though apparently drier, really contains a large percentage of water, but no glucose or similar material, and an arsenic content not much below the Disparene. It is by all odds the cheapest of the brands regularly on the market, so far as they have come under my notice.

The Cooper product was a special order, and ranks above the Target brand, but below all others, in arsenic. I understand that the price was about thirteen cents per pound, making it somewhat more expensive than the Eagle brand, than which it contains less water.

The Vreeland sample has a very high percentage of arsenic, and is said to be a new process material. It has never been tested, and is not yet regularly on the market, but if it can be produced at a satisfactory price it will deserve the fullest tests.*

The point to be noted is that, excluding this Vreeland sample, it required over three pounds of the Disparene and over four pounds of the Target brand to do the work of one pound of a fair quality of Paris green, and that it will require nearly four pounds of Target brand to do the work of three pounds of Disparene.

For the convenience of purchasers every manufacturer should print on the labels a statement of the minimum quantity of arsenic contained in his product as a guide to the strength at which it should be used.

No test for water soluble arsenic was made with any sample, but of the three kinds used by me, none caused any injury to foliage.

It was not intended to test or analyze all the brands of arsenate

---

* The material may now be obtained from the National Spice Company, 123 Maiden Lane, New York, at a price of 10½c. per pound, in 100-pound steel buckets; cans of one pound, 15c. These prices will probably stand reduction later.

of lead now on the market; simply to call attention to the variation in the amount of arsenic and price, and to give a basis of comparison with Paris green, which farmers have learnt to use. The *increasing price of Paris green and the decreasing price of the arsenate of lead may bring them nearer to an equality in economy of application, and then the arsenate of lead will be the most desirable material.*

Paris Green.

The sale of this material is now regulated by law in New Jersey and a large number of samples were analyzed by the chemist of the Experiment Station. The results of the work done were published in Bulletin No. 195, and need only to be referred to here. The important point to be noted is that almost all the samples, and all the samples of reputable manufacturers, come up to the required standard and contain no excess of water soluble arsenic. Wherever it can be used without danger to plant foliage this is still the most uniform, and, on the whole, the cheapest of the arsenical insecticides on the market.

Failures to obtain satisfactory results from its use are usually due to some neglect on the part of the users, but there is a small percentage of cases where the material has not been effective and where no apparent fault can be imputed to the operator. It seems as if some unrecognized condition might exist, climatic or otherwise, which in some way influences the resisting powers of the insects.

Antidin.

This is a powdery material of unknown composition received from Europe with the statement that it was used there with satisfactory results on *Phylloxera*. It was also claimed that it could be used against scale insects and that trees badly infested by the San José scale had been completely freed.

Unfortunately only a small sample was sent in, though more was promised, and it was impossible to carry out the plans made for its thorough trial. A material that kills the grape *Phylloxera* might be expected to act equally well on root-maggots, and it was with these that the chief work was to be done, but lack of material prevented.

The sample received was mixed with water, as directed, and remained suspended in flocculent particles, which sank slowly to the bottom. It was painted on the branches of an infested plum tree in an orchard and some of the foliage was wet with it to determine its action upon leaves. Two weeks later examination was made by Mr. Dickerson and neither foliage nor scales had been in *the least affected.*

A large supply of antidin has been ordered and experiments will be continued in 1907, on subterranean species at least.

Killarvae.

This is a material primarily intended for the destruction of *mosquitoes and their larvæ, but from its composition it seemed as* if it might possibly have a wider range. It consists of two powders, which if combined in water produce ammonia in sufficient quantity to be unpleasantly apparent. A reference to the section of this report dealing with mosquito matters will show that under some conditions the material was decidedly effective, and it was believed that it might be similarly useful as against root-maggots, while the ammonia produced might be of direct use to the plants. Unfortunately the manufacturer delayed sending in the supply ordered until the maggots had almost disappeared, and it was impossible to make any satisfactory tests. A large supply is now actually in hand, however, and will be used next season, if no unforeseen contingencies prevent.

To test the material on foliage, sprayed, on May 24th, some branches of maple trees near the laboratory. When the mixture was made a strong odor of ammonia was apparent, and the first lot was sprayed out without stirring. It developed in the process that the powders sank to the bottom quite rapidly, so that toward the end the spray was quite a thick mass. The second mixture was kept stirred while the spraying was done.

May 29th, the foliage sprayed with the first lot was somewhat burned where the material was thick, but had not been harmed where the beginning was made. The spraying done with the second lot, which was kept stirred, had hurt nothing; evidently it was the settlings that had caused the mischief.

August 4th, Mr. Dickerson made up a package of the material

and sprayed it on a badly-infested plum tree. Used so little water at first that the nozzle clogged, then allowed it to settle a little and poured off the liquid, which was then sprayed. On the 18th the foliage was slightly burned; the powdery coating on the bark showed obviously where the mixture had been applied, and while there were some crawling larvæ and recent sets some scales appeared to have been killed. On the 25th injury to foliage had intensified, while larvæ and recent sets were as abundant as ever.

September 29th made up another lot of the mixture and sprayed a small, badly-infested peach tree, which had plenty of crawling larvæ and recent sets. The tree had had a coating of carbolic acid on the trunk earlier in the season and showed a powdery, white appearance after the application had been made. Next day the powdery appearance was quite as well marked, but there were as many crawling larvæ as before and there was no evidence that any benefit had been derived.

Miscellaneous.

White hellebore and *ground tobacco* were tested as to their effect upon root-maggots on cabbage and onions, but the details of the experiments come rather with the account of these insects. The materials to be used were purchased by the Station and sent directly to the growers who had agreed to use them in accordance with directions. Mr. Dickerson, under instructions, visited each of them, and explained carefully what was desired, besides leaving a typewritten sheet on which everything was also set out in detail.

Lime and Sulphur Washes.

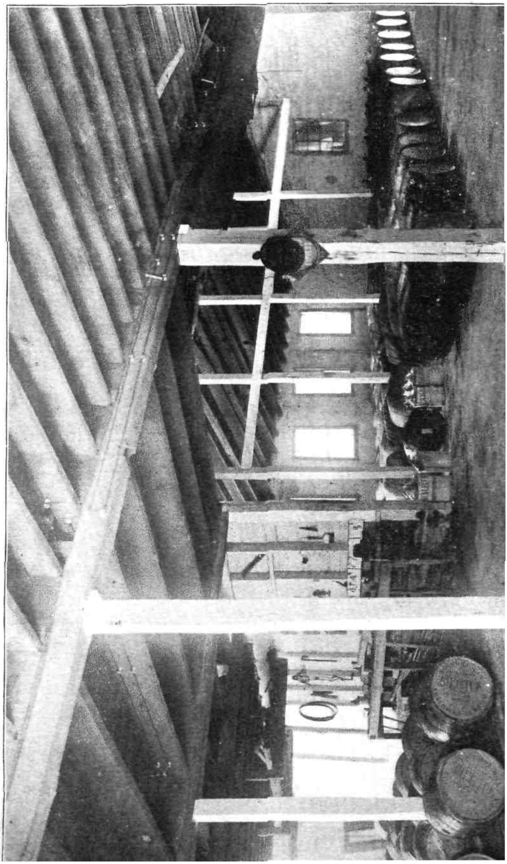
These combinations Mr. Dickerson has found in very general use, especially in peach orchards. The wash has been made in various ways and the ingredients were used in varying proportions. Within certain limits this variation does not seem to impair effectiveness, and where carefully made and applied the results *have been satisfactory on peach, and to perhaps a slightly less* extent on plum and young apple trees. Where it has been applied to old apple and pear trees on which the bark has become rough and scaly, the results, on the whole, have not been satisfactory, except where very thorough applications have been made with great force,

or where two sprayings have been made. The unsatisfactory results are due apparently to the fact that the insects are protected to a greater or less extent by the rough bark, or by plant hairs, or that the trees are large, and it is hard to reach all parts and cover thoroughly. In other words, the trouble is mechanical, and is due largely to the character of the wash, which tends to form a coating over a crevice or velvety surface rather than to penetrate into or through it. Brought into direct contact with it, the wash kills scales as readily on apple as on peach. On some pear trees the waxy surface forms an additional obstacle, because the wash will not stick in an even coating, but will run off in streaks.

While some of the sprayers used equal proportions of lime and sulphur, many preferred an excess of lime, and the tendency was to reduce the amount of salt or omit it altogether. Those who used the mixture without salt claim very satisfactory results. In the Hunterdon county districts, near New Germantown and Lebanon, the 40 lime, 30 sulphur and 20 salt to 90-100 gallons of water, is in favor, and some of the farmers boil for their neighbors, while some buy the mixture from dealers in spraying machinery, etc., who make up any desired quantity on order. This is convenient where no great amount of material is needed and the bother and expense of fitting up a boiling plant is a bar to a use of the material.

In making the combination, some, especially those who have had little experience, depend upon the length of time recommended for *boiling to obtain a good mixture, but as a rule those who have* had experience depend rather upon the appearance of the mixture, and when it has obtained the right color and consistency consider it ready for use, irrespective of the elapsed time.

Only one or two cases of using *self-boiled mixture* are recorded. One of these is a grower near Riverton, who has been successful with such a combination, not only on peach, but also on old, bearing pear and apple trees which in the past were very scaly and are now clean. The success in this instance is due to first-class materials and first-class work. A sufficient excess of lime is used to obtain the heat necessary to make the combination, hot water is used in slaking, and as soon as the materials are mixed and the lime is boiling, the barrel is covered to retain the heat. The application is not only made with great force, but in such excess that a complete coating is formed and every crack or crevice is filled.



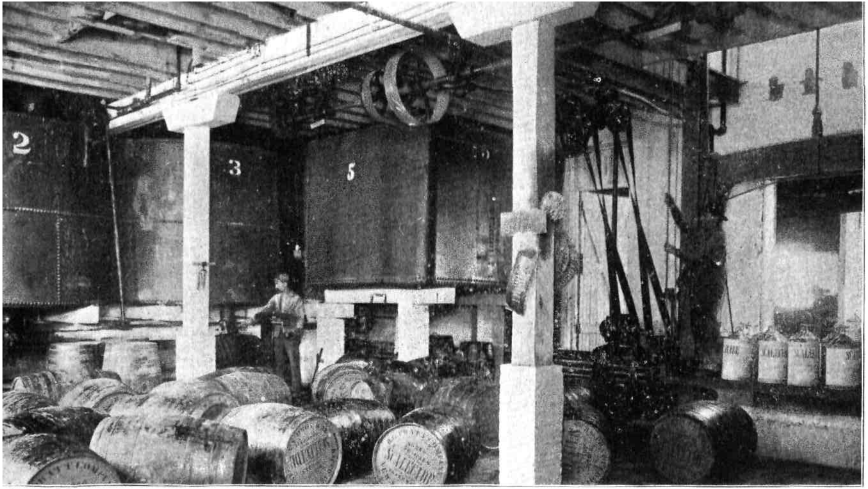
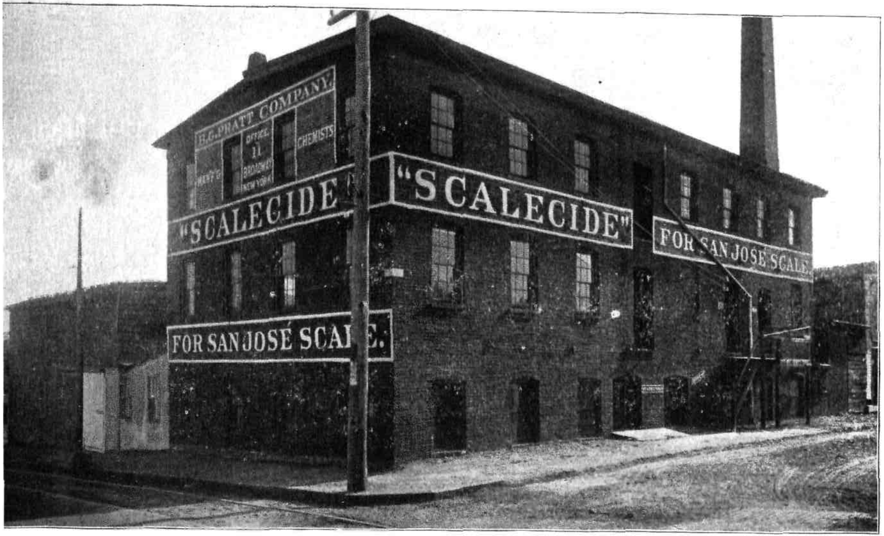


Fig. 28.

Mixing and filling rooms in Scalecide Laboratory, showing three of the five mixing tanks; capacity of each one carload. From a photograph.


B.G. PRATT COMPANY.
MANF'G
OFFICE
11
BROADWAY
NEW YORK
CHEMISTS
"SCALECIDE"
"SCALECIDE"
FOR SAN JOSÉ SCALE.
FOR SAN JOSE SCALE

Lime, sulphur and *caustic soda* has also been used successfully, but probably to a limited extent only. Near Madison, Morris county, large bearing apple trees were seen which were treated with this combination in 1904, and from which the scales had almost completely disappeared. Some plum trees treated in the same way showed almost equally good results. Here also good materials and thorough application counted heavily toward the result.

Those who have used the lime and sulphur mixtures longest and with greatest benefit now understand their limitations fairly well, and do not expect to obtain impossibilities. They realize that the *right mixture must be obtained, and that it must strike the scale to kill.* They realize also that the mixture goes only where it is put, and that it has no spreading or creeping power.

I advise this mixture for use on peach trees in preference to any other because of the benefit derived by the trees, irrespective of the removal of the scale. Peach trees seem to be more easily covered than any other variety of fruit, and the measure of success is proportionately very great. With a full understanding of the limitations above noted, the peach grower really needs nothing more effective.

As to the proportion of materials to be used, I still prefer for the boiled mixture equal quantities of lime and sulphur, provided the lime is good. If it is of poor grade, more is necessary to get the quantity of actual lime that is needed. The consensus of opinion, based on results throughout the country, seems to be that the salt is neither essential to secure an insecticide effect nor of benefit in forming the combination of lime and sulphur

SCALECIDE.

"Scalecide" is now made at Hackensack, New Jersey, in a brick building, close to the line of the Susquehanna and Western railroad, a siding from which runs the oil cars to a point whence it is drawn directly from them to an underground tank outside the factory. Connected with the main buildings are storage and shipping sheds of ample capacity for the prompt and economical handling of the crude and manufactured products.

Concerning this outfit, which was visited by Mr. Dickerson and

myself early in November, Mr. B. G. Pratt writes: "The factory has been arranged with every labor-saving device, with a view to *the most economical production of 'Scalecide.'* All raw material is handled by pumps or gravity, giving the chemist in charge the personal control of all raw material without depending on unskilled labor, thus insuring uniformity and exactness throughout the whole operation, and nothing is left to guesswork."

We found the work in progress when we arrived and oil was being pumped from the underground tank into one of the large mixing tanks, of which there are five on the lower floor. Each of these tanks has a capacity of thirty thousand pounds, or a carload of the finished product, and the materials enter from the first story through openings in the floor, from which, also, the process of mixing can be observed by means of electric drop lights. As soon as the gauge shows a proper amount of mineral oil in the tank, one of the vegetable oils is added from barrels—four barrels of the prepared oil which is stored on this first story being run in while the agitators are started to form a homogeneous mixture. On the second story is a large metal tank containing another prepared vegetable oil treated to assist in combining with the mineral oil, and from this a definite quantity, registered by gauge, is next run in. The agitators, when once started, continue their work unceasingly, and from time to time samples are drawn and tested in the laboratory, which is on the floor from which all materials enter the mixing tanks. When the samples drawn indicate a uniform mixture, the alkali and water is added in the correct proportion, and testing begins again until the proper reaction is obtained by the most delicate tests. When this reaction is satisfactory the mixture is complete as to materials and it dissolves or mixes readily with water. It is then tested for stability and agitation is continued until no "cream" separates from the diluted material. Mr. Pratt writes further:

"As each tank is started a consecutive number is given and a complete record made of same. Samples are drawn, labeled and tested, and preserved for future reference. The tank is allowed to stand for at least twenty-four hours after finishing, and then other samples are drawn and tested before receiving the O. K. of the chemist, after which contents are drawn out into barrels and cans, each numbered with the corresponding number of the tank and sample, a record of which is again made on each shipping

order, by which reference to the sample and date of manufacture can be made of any individual shipment at any time by simply giving this number. The greatest care is exercised throughout the whole operation, and finally each barrel is inspected before shipment is made."

It may be added that while the product is drawn from the tanks the agitators are working constantly, so that there is no possibility of a separation or of a difference between barrels of the same lot. The final test from barrels is simply drawing a small sample *through the bung hole and dropping into a glass of water. If it* dissolves readily and completely into a milky-white emulsion it is passed; if there is any delay in the mixing, or any unusual appearance is noted, the sample is referred to the chemist. The capacity of the plant is three carloads per day.

Concerning the material that goes into the making, Mr. Pratt gives information as follows: "'Scalecide' is not an 'accident,' but the outgrowth of many years of study and experiment on the solubility of oils. In the course of these experiments every known commercial oil has been treated and rendered soluble, both alone and in combination, so that when, in the fall of 1904, Professor Smith suggested the need of a petroleum that was readily and perfectly miscible in water, it was simply a matter of ascertaining *the cheapest and best combination* that would do the work. Samples of commercial and specially prepared petroleum were obtained from different sources, and finally a partially refined goods was decided on, the light inflammable and the heavy oils being removed, at the same time retaining all the sulphur solutions that are present in most crude oils.

"The next step was to ascertain what other oil or oils in combination, when properly treated, would combine with the largest proportion of this petroleum oil, opening up the globule and allowing the free action of an alkali.

"It might be of interest to those who do not understand the chemistry of fats and oils to say that *the only difference between* petroleum oil and the animal and vegetable oils that can be saponified *or turned into soap is simply one atom of oxygen.* If this one atom could be added to all the hydro-carbon combinations in petroleum, a cheap petroleum soap would be possible. As it is, petroleum oil is not acted upon either by the strongest acid or alkali.

"By combining these oils in the proportion of 75 parts of petroleum, 25 parts of combined vegetable oils, to which is added 8 to 10 parts of water and chemicals, the result is a neutral product, which is the nearest approach to a pure petroleum soap that has ever been made. This, on account of its liquid oily appearance, is called soluble petroleum."

As to the cost of the material, the vegetable oils and chemicals used, although forming only 20 per cent. to 25 per cent. of the whole combination, cost four or five times as much as the 70 per cent. petroleum which it contains.

The petroleum which is used is of a brown color, not unlike the usual appearance of ordinary crude, but it lacks the light gasolines or naphthas, and is practically free from vaseline. In its raw state it is therefore not nearly so diffuse as undiluted crude, and, on the other hand, it leaves no penetrating greasy residue of vaseline or paraffine to work into the plant cells. The vegetable oils dry out before they soak in, but they have a tendency to bring the scales into close contact with the bark, and the scurf may remain for an entire season, sometimes giving the trees the appearance of being badly infested when not a living example can be found. At other times the bark may clean up completely, leaving little or no scurf remaining. As the material is completely soluble, all traces of actual combined oil will be washed from the trees. It is almost impossible to injure a dormant tree with "Scalecide," diluted in any reasonable way, and successive applications do not produce a cumulative effect, because no residue remains to accumulate.

A few points developed in reply to questions. Mr. Pratt admits the possibility of a separation of the oils in combination under conditions not well understood, but contends that the separation is more apparent than real, and that a little shaking up will restore the union. It is to discount this unlikely separation that the direction is placed on the outside of each package—"Shake well before using."

The water in combination is necessary to the emulsion, and the loss of any considerable part of this water will impair its solubility. Long standing in dry barrels may cause a loss of water, and hence it will be better to test old material by placing a few drops in water before beginning to use. If it dissolves readily it is all right; if there is any difficulty, add two cups of water to a barrel of "Scalecide" and stir thoroughly. This should restore the

ombination, but if not, add more water to the extent of a gallon, nd there may even be an excess. An excess is indicated when the naterial changes to an opaque, creamy tint instead of remaining clear brown liquid, but the excess will not affect the material so s to prevent use or lessen effect. An important recommendation s that the "Scalecide" should be poured into the water instead of vater into "Scalecide." If the oil is put in first and water is dded, there will be adhesion to the sides of the vessel and the ormation of masses which disintegrate slowly. If the oil is poured nto the water it mixes readily. It does not matter how cold the vater is, although it does not dissolve as readily at thirty-two degrees to thirty-five degrees as at fifty degrees to sixty degrees, but ot water should not be used. Cold does not affect the combination, but heat may do so by causing the loss of water in the emulsion, hence do not store where the temperature gets above seventy legrees if it can be avoided. Mr. Pratt assures me that their offer o replace unsatisfactory material is made in good faith, but they annot, of course, undertake to guarantee effect where so much lepends upon the user. They assume liability only for defects in he material due to their neglect or failure, and it is to bring out ossible defects in their methods that they retain samples from ach lot sent out.

After going through the factory and watching the process of making up a carload, and examining the methods of checking, filling nd shipping, it seems almost impossible that there should be any naterial difference in the product sent out, or in the percentage of ctual petroleum oil in the different lots. Differences in results nust be due to factors outside of the composition of the material tself; but for his own protection and to make certain of the best onditions as to material, every purchaser is advised to use the ollowing precautions:

On receiving a lot of "Scalecide," make a note of the number f the emulsion or lot on each barrel or can. Always shake or nix up well before opening. Test by taking up a spoonful and llowing it to drop slowly into a glass of water; if it dissolves eadily and completely and forms a milky emulsion, it is in conlition for use. If there is trouble in dissolving, notify the maker f it is a fresh lot; add a little water if it is old. Always put the vater, or at least a large part of it, into the spray tank first and our the "Scalecide" into the water slowly. The resulting emul-

sion should be an absolutely even milky-white liquid, without scum or sediment, and it should remain of the same texture throughout the work. In test tubes the emulsion should remain perfect and without separation, either to bottom or top, for several days.

Used with these precautions any differences in the results obtained cannot be charged to differences in the material, and if a good effect is noted from one application the reason for the failure of another must be sought outside of the composition of the insecticide.

Examinations Made.

In the course of his inspections, Mr. Dickerson examined orchards treated with "Scalecide" in the Hunterdon county peach districts, at many points in Burlington county, at several points in Morris county, in large sections of Mercer county, a few in Middlesex county and a number in Cumberland, Monmouth and other southern counties. These orchards, containing many thousands of trees, were peach, apple and pear, in the order named, and also a few plum and other of the usual fruit trees. His conclusions, based upon these examinations, are that the results have been, on the whole, good, but very irregular, and he suggests several reasons for this—*first,* too great a confidence in the killing power of the material, leading to a careless application, and the belief that it would work around any branch and through any mass of scales, however thick; *second,* used at the strength of 1 to 20, the mixture contained only a small percentage of oil, and, unless very thoroughly applied, not enough actual oil reached the trees to be effective; *third,* the mixture dries rather rapidly and does not leave any deposit or mark to show where it was applied; as a result, unless the work is very carefully done, some parts of the tree are apt to be missed. That the material will do the work, where thoroughly applied, was shown in numerous instances. As an illustration, a badly-infested plum tree was sprayed to a drip, with the result that in the midsummer following it was yet free from live scale. This was one especial instance in a large orchard where it was intended to give the material a severe test, the rest of the trees receiving a more moderate treatment. It simply meant that where enough of the material reached the tree it did the work required. In all cases it mixed well with water and sprayed nicely, for which reasons and the ease of application it was much liked.

"The result of the work is that some who have failed with it will spray with lime, salt and sulphur the coming season; others who had fair success with it will give it another trial, while those who were successful will continue to use it. In all cases I have urged very thorough work and a stronger mixture, and from all I could learn I believe the tendency to be in this direction the coming season."

In a number of cases two applications, fall of 1905 and spring of 1906, were made, and usually with excellent results. In others "Scalecide" was applied in fall, and lime, salt and sulphur in spring, and in one large orchard, so badly infested in 1905 that the fruit was largely unsalable, the insect was almost completely eradicated. The owner referred to this in a letter dated in November, when he mentioned the scale as a "rare bird" on his place.

On the Experiment Orchard "Scalecide" was used in the fall of 1905, and the trees remained in excellent condition throughout 1906, as appears in another part of the report.

An orchard of large apple trees, very badly infested, located not far from New Brunswick, was sprayed with a 1 to 20 mixture through the Niagara sprayer belonging to the Station, under Mr. Dickerson's supervision, in the fall of 1905, and again early in April, 1906. Examination made November 1st by Mr. Dickerson and myself showed some trees almost entirely clean and others, badly infested the year before, in very fair condition, all the fruit seen being fairly or altogether clean. It was also noticed here that the last year's scale covering still remained plastered on many trees, giving the appearance of a worse infestation than actually existed.

The Dickerson peach orchard near Chester, Morris county, containing between five and six hundred bearing trees, variably infested, were sprayed November 9th to 11th, 1905, with the 1 to 20 mixture, and the trees remained in good condition throughout the season, though by no means free from scale at the end of the season.

Experiments were also made with the mixture as a summer application on apple, peach and plum, with the result that it can be used after midsummer with good effect and a fair degree of safety, but on the whole such applications are not advised except on trees so badly infested that the life of the tree is threatened.

Recommendations.

The net result of all the work done by or through the office an in the orchards under all sorts of conditions by all sorts of men i that confidence in the mixture as a scale-killer is justified. But t obtain reliable results, the 1 to 20 mixture is too weak. It contain only about 3½ per cent. of actual oil, and this will not be sufficien to penetrate a thick layer of scales; 1 to 15 will be much mor effective, and even that should be very thoroughly applied. Fur ther, because of the practical difficulty of reaching all parts o large trees at any one application, two sprayings are advised, on in fall and the other in spring. There need be no fear of injur from even the most thorough applications at this strength.

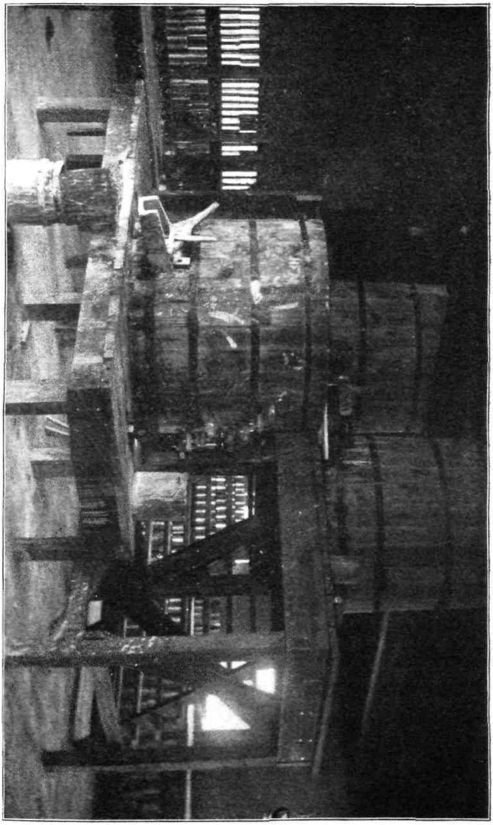
TARGET BRAND.

"Target Brand" scale destroyer is a petroleum combinatio made by the American Horticultural Distributing Company, a Martinsburg, W. Va. I visited their plant in the late fall of 1905 and by the courtesy of the president of the company, Mr. John W Stewart, and the then chemist, Dr. P. Karutz, I had an oppor tunity to examine the outfit for making and to learn the composi tion of some of the insecticides made by the company. In respons *to my request, the photographs illustrating this report were sen* me and also the matter in quotation marks in this account.

The plant consists of a three-story building fifty by one hundre and fifty feet, in which the actual manufacturing is done, and one-story building fifty by one hundred, which contains storag rooms for the mineral and vegetable oils, as well as engine an boiler-room. The lower floor of the larger building is devote largely to the shipping department; the middle floor contain laboratory, salesroom, shipping and finishing departments, whil the distilling, mixing and other manufacturing is done on th third floor. A siding from the Cumberland Valley railroad run directly to the building and facilitates the receipt of supplies an delivery of products.

"This soluble oil is composed of a combination of vegetable an non-penetrating mineral oils, made by a very expensive and carefu as well as tedious process of blending and cooking. The fact tha

Fig. 30.
The Target Brand Scale Destroyer Building at Martinsburg, W. Va. From a photograph.



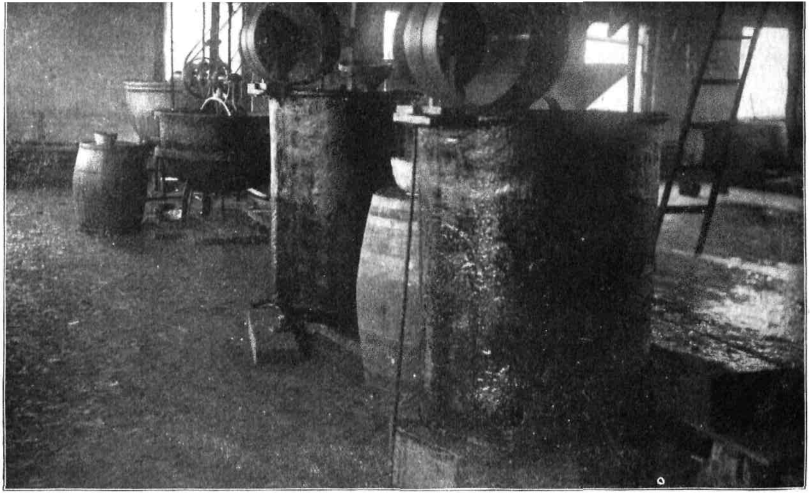


Fig. 32.

A row of mixing machines in Target Brand Laboratory. From a photograph.

we can only manufacture one carload per day will no doubt look like a small one, in consideration of the amount of power and room we have, but that is all that can be made with the present amount of machinery."

"We are also sending you some photographs of both the interior and exterior of our plant, which we trust will give you some idea of the heavy expense that is necessary to make a good product. Every department has to have careful and trained men in order to insure a uniform product, and in fact it must be uniform or it is nothing. To insure this it takes the careful and ever watchful eye of a good, experienced chemist, well versed in the handling of both vegetable and mineral oils."

"The product which we are now manufacturing is the result of many years of hard work, careful study and endless experiments, added to thousands and thousands of dollars spent to accomplish the same. We have made dozens of different soluble oils and experimented with them, some of which were satisfactory so far as killing the scale went, but left a damaging effect from the oil upon the trees."

"We found that in order to make a product to kill scale it must be done without penetrating, but by suffocation. At first we made it with too much body and closed the pores of the trees, which was as bad if not worse than the penetrating, but after several more years we got a basis which, from all appearances, seems to be right, and is right to the best of our knowledge."

"The present product is by far the most tedious and careful as well as expensive of all the different experimental products which this company has made and applied on the two-hundred-acre experimental orchard which is run in connection with this plant."

At the time of my visit the factory at Martinsburg was not running, but I saw the machinery for mixing the oils and in the laboratory was shown, in an experimental way, the combination of the materials. A very high percentage of mineral oil is claimed for this combination, and experimentally the combination can undoubtedly be made. Any process reducing the amount of the emulsifier will reduce the price of the combination, of which the crude oil is the least expensive material. Yet on this point Mr. Stewart writes, "but owing to the very small margin of profit at the present prices, we do not feel that it would be a paying invest-

ment to increase the same," speaking in that connection of the capacity of their plant.

I have no direct information as to the methods of testing the material sent out or of controlling it, but have seen no reason to doubt the uniformity of the product. The same tendency to a separation found in the other soluble oils is undoubtedly to be provided for here, and all the precautions recommended under "Scalecide" should be observed with this material as well, though the distillate employed as a base is different in composition.

"Target Brand" is sold in New Jersey and has been used in various parts of the State, but somehow neither Mr. Dickerson nor myself had any opportunity of examining trees treated with it, hence I am unable to speak of its merits from personal experience. I see no reason why it should not be quite as effective as any other of the oil preparations, and in speaking of "soluble oils" always mean to include it under that general term.

Kill-O-Scale.

I have no personal knowledge of the conditions of or manner in which the manufacture of this compound is carried on. In composition it approaches Scalecide very closely, but has a considerable admixture of free sulphur. This may, under some conditions, add to the killing power of the material, but not to the extent of doubling its money value.

All that has been said as to the manner of using Scalecide will apply here as well, and there is no reason for believing that it will not be quite as effective. Only a few places were found where Kill-O-Scale was used, its price acting as a bar, and in none of these instances was it used alone or so that its effectiveness could be justly determined.

Scale-Skidoo.

A can of this material was sent in for trial by the Gould Chemical Company, of Arlington, N. J., early in June, with the statement that it had been successfully used by a number of persons against the pernicious scale and other insects. Three addresses were furnished, on request, of those who had used the mixture, but for a variety of reasons they were not followed up, the material offering a chance for a successful summer wash.

A practical difficulty in securing dilution with water led to a correspondence in which it was learnt that it was proper to "add the water to the material instead of the material to the water. Our preparation is an oil emulsion, not a soap; neither is it saponified in any way." * * * "It should be diluted with water when ready to use, as all emulsions will separate after being mixed with water for some time, although I have used it myself after it had been mixed in spray pump for two or three days with good results." It was also learned that there was 95 per cent. of oil in the emulsion, but that there might be a slight variation.

The material had a very decided odor of kerosene when opened, and it was noted that there was a covering of clear oil on the surface, which combined with the sediment on shaking and then made a thick, light reddish-gray emulsion. To test its stability, 22 cc. was poured into a test tube and allowed to stand twenty-four hours. It had then separated into four layers, as follows: First, at bottom, 2½ cc. of a dirty reddish-cream color; second, a film of whitish cream between layers first and third; third, the mass of material of a lighter reddish-gray and creamy in consistency, and fourth, a thin layer of oil. All these combined readily on shaking, but separation began again as soon as quiet was restored.

The 1 to 20 dilution was also tested, and to 12½ cc. of Skidoo, well shaken up, 237½ cc. of water was added, making a total of 250 cc. The material dissolved readily and formed an even milky mixture with a slight scum on the surface. Within an hour there was 2 cc. of clear oil on the surface, and after twenty-four hours 10 cc. of clear oil was on top—nearly all there was in the combination—and the balance was a whitish watery mass. This could not be recombined, and after thorough shaking again the oil rose to the surface.

August 18th, applied the 1 to 20 mixture to a small, very scaly apple tree. August 25th, there was little injury to foliage, except at the tips on two limbs, which the leaves were distinctly burned and brown. There were plenty of larvæ and recent sets.

September 29th, the same combination was applied on a plum and on a peach tree, both pretty well infested by scale. Next day the plum showed no signs of injury; there were plenty of crawling larvæ, and it was doubtful whether more than the larvæ actually crawling at the time of the application were killed. On the peach tree the results were similar

The Camden Mixture.

This is a combination by Mr. E. O. Huber, of Camden, New Jersey, and was sent in for trial April 6th, 1906. It appeared to be a resin and petroleum combination, which was unstable in character and separated on standing. Mr. Huber was advised of this fact and sent a somewhat larger quantity about the middle of May, and this combination appeared to be stable.

The directions were to use it at the rate of 1 to 40 or 50 as a summer mixture, 1 to 25 as a winter mixture, and successful use was claimed in Burlington orchards. It was to be shaken up a little, then put in water gradually, at the same time agitating just enough to dissolve.

The first test was for stability of the diluted mixture, and we found that the combination 1 to 50 would stand for several days without separation, meeting every requirement that could even be reasonably made in a practical use.

The next test was as to injury to foliage, and it was found that at 1 to 50 and 1 to 25 there was no injury to maple leaves, these being about as susceptible as any within our experience.

Owing to the small sample, as well as press of other work, no orchard tests were made until August 4th, when Mr. Dickerson sprayed a scaly plum tree with 1 to 20 and a scaly peach tree with 1 to 40.

Two weeks later the plum tree showed some burning effect; some of the leaves were entirely brown and dry, others were somewhat scorched but on the whole the injury was not serious. As to the scales, many had been undoubtedly destroyed, and that more were not killed was due in part at least to the fact that the foliage prevented the spray from reaching the infested wood. There were quite a number of new sets and active larvæ. As compared with a neighboring tree of the same kind sprayed with Scalecide at the same dilution, this showed a somewhat greater burning and rather more recent infestation. The peach tree was uninjured and so were the scales infesting it.

September 29th, sprayed with the 1 to 20 dilution one small bearing apple rather slightly infested; one medium-sized bearing plum badly infested, with many recent sets and active larvæ; one

medium-sized bearing plum of irregular growth and with some of the branches very badly infested.

September 30th, none of the trees showed injury to foliage. The apple had some fresh sets and some active larvæ, but there had been, undoubtedly, a material reduction. The first of the plum trees showed very few active larvæ, and such recent sets as appeared may have been there before the application. The second of the plum trees showed quite a number of active larvæ and fresh sets.

On the whole this mixture has not had a sufficient trial to make it fair to speak positively. It is made up in very small lots only and varies a little in composition, but at the rate of 1 to 40 or 1 to 50, as advised, it will prove absolutely ineffective, simply because no combination containing so small a percentage of petroleum can do any good.

Mechanical Emulsions.

Very much to my surprise Mr. Dickerson found the mechanical mixture of oil and water in high favor and very effective in all cases. He writes: "The oil and water mechanical mixture has been much more extensively used than the undiluted oil, and, so far as I know, the material was crude oil rather than kerosene, applied with a Kerowater pump. I have seen both peach and apple so sprayed in several localities with excellent results. Quite a number of the peach growers will continue to use the mixtures, and others who did use it, but are now using lime, sulphur and salt, did not change because they had not been successful, but because they feared that injury might come from continued applications and because they believed the lime-sulphur washes to be more beneficial to the trees. The tendency, at least in spraying peach trees, is to reduce the proportion of oil in the combination. At first 25 per cent. was used, but now 15 per cent. to 20 per cent. is generally employed. An orchardist near Lambertville furnishes a good example of what has been done with this material. He started to spray five or six years ago with the 25 per cent. mechanical mixture on both bearing apple and peach trees which were more or less scaly. He felt, however, that he was getting too much oil on his trees and reduced it to 20 per cent. This year he sprayed some young peach trees with 15 per cent. I saw the peach orchard which

was first sprayed five or six years ago and every year since. Th trees are seven years old, in fine condition, very free from scale they had borne well and had, when I saw them, so large a crop th it was necessary to thin to prevent them from breaking.

"A White-House orchardist has had a similar experience an now uses a 15 per cent. mixture of oil and water. But he says th while he uses a smaller percentage he actually gets as much oil o the tree, because he sprays longer and covers more evenly. He say he has never noticed injury, and I examined the peach orchard that had been so sprayed for several years and found the trees i fine, healthy, clean condition.

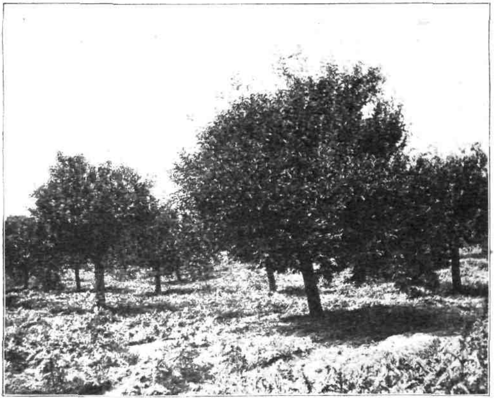
"In one or two instances careless application, which resulted i getting on too much oil, injured peach trees, but in general thos using the mixture judge the strength by the appearance of th spray and have learnt to recognize when they get either too littl or too much.

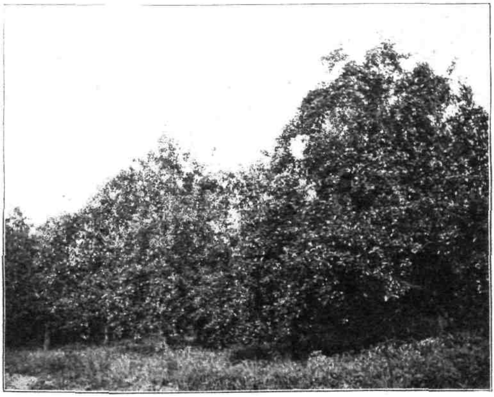
"Several of those using the Kerowater pumps say that they d not always distribute accurately, giving a little too much water o the start, but in general the pumps seem to have worked quite satis factorily and to have given good results."

The interesting feature in this record is that applications o peach, our most susceptible fruit tree, continued for five or si years, have caused no injury or accumulation of injury, thoug from 15 to 25 per cent. of actual oil has been used. It is importan as bearing on the question of whether repeated applications of th soluble oils can cause injury, and would indicate a reply in th negative, since these, as applied, contain only about 4 per cent. o actual oil.

Crude Oil.

Crude oil, in one form or another, is still considerably employe throughout the State, the "insecticide oil" of the Standard Oi Company being the most usual. It is used by few peach-growers more by growers of apple and pear, and in some cases grower that have failed to destroy the scale on their large, bearing tree with the lime, salt and sulphur wash, are using crude oil with suc cess. Most of the men that use it now understand its penetrating character, and know that while this makes it a scale-killer of th first order, it also makes it dangerous to their trees when care-





lessly handled. Personal experience has in many cases impressed this upon men who are still using it.

Wherever the oil hits it kills, and if treated trees have not been cleaned it simply means that they have not been thoroughly sprayed. The undiluted oil also shows wherever it has come into contact with the bark, and where I have found live scale on apple trees sprayed with this material I could see just where the oil had not been applied. This is apt to happen where the grower is afraid of getting too much oil on his trees and does not spray thoroughly enough. Some growers have warmed the material before use and claim that it is more penetrating and spreads and covers better than when cold.

Thus far I have quoted largely from Mr. Dickerson's report, and the "I" in the last paragraph is his. Personally I have seen apple trees of large and medium size, so badly infested with scale that they were beginning to die at tips, cut back and sprayed with undiluted oil, afterward recover and make good useful trees. One case especially, in Burlington county, was brought to my attention. When I saw the orchard in the spring of 1905 I would not have given a dollar for its chance of life. The trees were all topped, some of them cut back to stubs, and all were bright chocolate-brown and greasy. Some were starting out, but I would not have been surprised to learn later that the orchard had been cut out. The owner insisted, however, that the trees would come out all right, and he was correct. The photograph here given illustrates the condition of the trees in the summer of 1906, and there was a crop of clean fruit on them. The rest of the farm was cleaned up by a fall application of Scalecide, followed by lime, salt and sulphur in spring. It is further suggestive that this same man is constantly putting out more trees, with full recognition of the fact that he will have to fight scale on them almost from the start.

Kerosene Limoid.

K.-L. has not been very extensively used in New Jersey, so far as our observations extend, and only two cases have been actually verified. In Salem county a nurseryman combines the treatment of trees with the business of growing them, and charges ten cents per gallon of applied mixture. Four thousand five hundred gal-

lons of K.-L. were used and in every instance the application was liberal, since there was no inducement to economy, and the dealer rightly claimed that unless he was allowed to do the work well he could not guarantee a good result. The formula was five gallons of kerosene, twenty pounds of limoid and twenty-five gallons of water, making an actual proportion of one-sixth, or about 16 per cent. kerosene. The oil and limoid were thoroughly mixed together with a hoe, and then, by a like process, the water was mixed as added, and what appeared to be a good combination was obtained. Whenever the infestation was bad a second application was made. So far as the examinations extended the results were good, even where only a single application was made. In only a few cases they were unsatisfactory on old, bearing apples, but in one instance this may have been due to rain coming immediately after the spraying was done. The effect on the trees was not so uniformly good. Apple and pear were safely sprayed in all instances; plums were sometimes injured and young peaches were in some instances killed.

The results prove that the K.-L. will kill scales where used liberally, and will also kill some trees where enough oil gets on them. It is fair to say, however, that the method of mixing was unsatisfactory and not calculated to secure the best results as against the scale or the greatest measure of safety to the trees.

To make an even mixture and get a real emulsion, stirring with a hoe is not enough. There should be a thorough churning by pumping the material back into the tank until it has all passed through the pump at least once and has been forced through the nozzle back into the mixture again with pressure enough to stir it up violently. The injury caused was probably due to free oil contained in the spray as applied.

In Passaic county an orchard of about one hundred and thirty large apple trees was treated for two years in succession with the combination containing about 20 per cent. of kerosene. At the date of inspection, March 22d, 1906, the trees seemed to be in very fair condition, and very little living scale was observed. Later examinations were not made, owing to press of other work.

Carbolic Acid.

This material is not new as a scale-killer, but was tried and abandoned for various reasons soon after experiments began in New Jersey. Nevertheless, reference to it cropped up again in the "Rural New Yorker" and the "American Agriculturist," two of the agricultural papers most widely circulated in New Jersey. The note in the "Rural New Yorker" was as follows:

"An Annandale writer in the High Bridge "Gazette" says: Several of the peach growers in this section are applying crude carbolic acid to their trees to kill the San José scale. John Shurts, of this township, tried this remedy for the scale last year, and says it is a complete success. The acid is applied with a brush to the trunk of the tree to about three feet from the base, when the sap is running up. It is claimed that the acid gets into the sap and is conveyed to all parts of the tree, killing every scale on it. The growers claim that the fruit is not affected by the acid, while the trees are much invigorated. Jeremiah Hall, of Stanton, was the first to discover the value of the acid as a scalecide. The advantage of this treatment over the old is that it will kill the scale after a tree has become affected with it, while nearly all of the old remedies were merely preventives."

The note in the "American Agriculturist" was longer, but covered the same subject:

"A Hunterdon county man, J. H. Hall, has come out with a new remedy for the San José scale. It is crude carbolic acid simply brushed on the trunk of the tree. He and two other fruit growers personally known to the writer have tried it for two seasons, and give strong testimony to its beneficial effects. According to their experience, it means the entire riddance of the tree of this insect pest, but how it does it is not explained. Whether it is the persistent fumes of the stuff constantly arising through the treetop, or whether it works some slight change in the sap of the tree which makes it unwholesome to the scale, can as yet be only surmised.

"The latter version is usually considered among the impossibilities, but reports of some recent experiments on the current number of the 'Scientific American' do prove that chemicals may enter the sap of a tree and have effect on its health. This, taken in connec-

tion with the fact that insect life is sensitively affected by the food on what it lives, may lead into a new field of investigation.

"The originator of this carbolic treatment says that it is necessary to merely paint a band of the chemical around the trunk. This sounds much like quackery, but the disinterested testimony of those who have tried it and the cheapness and ease of application of the remedy makes it worthy of a trial.

"Farmers in these parts have mostly given up their apple orchards, but there are still quite a number of peach orchards kept in condition by the lime, sulphur and salt treatment. The only peach orchard I have seen, however, that looks like the old-time vigor and health is the orchard of Mr. William Hoffman, near Lebanon, N. J. He has used nothing but lime and sulphur mixed without boiling."

Mr. Dickerson was detailed to look into the matter and he found Mr. Jeremiah Hall, who very kindly drove him to all the places where the carbolic acid had been used, and showed also his own trees where the original experiments were made. The publications above quoted were made early in June, before scale-breeding had started; the examination by Mr. Dickerson was made August 1st, when the second brood was on the move, and when infestation was much better marked where it existed.

Of the trees examined, including the usual orchard fruits, some had received belts a foot wide, and from that varying to the whole trunk and the bases of the branches. Crude carbolic acid, "best quality obtainable," was used, and wherever it covered the insects it has killed them, without apparent harm to the trees in any case. There was no case, however, where any interference with normal breeding was observed outside of the directly treated space, and on most of the trees an abundance of crawling larvæ and living sets was seen. Mr. Hall's own trees were but slightly infested, but there was no evidence that they had ever been worse, and seem to constitute one of those curious exceptions to the general susceptibility that are sometimes discovered. A marked instance of that was noted in Montclair, where a series of infested plum trees became almost entirely free during the past winter, though no treatment whatever was made.

In late fall, while making nursery inspections, Mr. Dickerson ran across an apple orchard of some size in another section of Hun-

erdon county which had been treated to a carbolic acid banding arlier in the season with absolutely no good result.

The only direct experiment was made by Mr. Dickerson on a nall bearing peach, very scaly, the trunk of which was painted ith the crude carbolic acid August 23d. On September 29th here was no perceptible injury to the bark directly, or to the eneral health of the tree, while there were plenty of living scales ith fresh sets and crawling larvæ all over it. The same tree was iade the subject of another experiment on the later date.

It is a very attractive idea to treat the scale in so easy and inexensive a manner, and some farmers have suffered so much loss hat they are ready to grasp at almost anything that promises elief, especially if it is easy to apply and involves no labor in reparation.

Dr. B. D. Halsted, the botanist to the Station, informs me that ae outer bark takes no part in feeding a tree, and that there is no irculation through it. The sap is carried through the layer beween bark and wood and only the liquids prepared by the rootystem are carried through it. It would be impossible for carbolic cid to enter unaltered into the general circulation, and even if ll that could soak through the outer bark was carried into the ap as rapidly as it worked through it would be so diluted when it eached the leaves and twigs as to be imperceptible.

Carbolic acid is a good insecticide for some purposes and will ill the pernicious scale when applied to it, but there is no evidence t present that it will kill in any other way.

Whale Oil Soap.

This well-tried material has been used as a winter wash in a ery few cases, although frequently recommended and sometimes sed as a summer application.

One large peach orchard had been treated with soap for two iccessive winters, but in 1905-06 a change was made to the lime, ilt and sulphur wash. When examined by Mr. Dickerson the trees ere in excellent condition and the orchard was very free from ale.

In another locality some large, bearing plums had become so aly that it was a question whether to take them out or let them

stand. The latter was finally decided upon and they were thoroughly sprayed with whale oil soap. When examined in midsummer the trees were growing well, appeared to be in thrifty condition and very little live scale was apparent.

The excessive cost of the applied mixture is one of the chief objections to it, and the results have not always been so uniformly good as the above record indicates.

Caustic Soda.

Mr. Dickerson's notes are as follows: "Caustic soda, which was used by a number of growers a year or two ago, is not being used by any one at present so far as I know. One year's experience was enough to show the ineffectiveness of the material and the general comment of those who used it is—'Just one year behind in my orchard.'"

TREE TANGLEFOOT.

This is a preparation made by the O. & W. Thum Company, of Grand Rapids, Michigan, who are also the makers of the sticky fly paper sold under the same "Tanglefoot" term. It is of the consistency of soft putty, spreads readily with a trowel or wooden spatula and remains sticky for a long period when exposed to the outer air.

The material is recommended for banding trees where it is desired to prevent insects from traveling up or down the trunks, and a considerable quantity has been used in Massachusetts for banding trees in gypsy moth work.

I had the opportunity of seeing the treated trees during the season of 1905, and it seemed to me that some of the younger, smooth-barked trees had been injured, and I so informed the manufacturers in the course of correspondence. Meanwhile the material had been used in California on a great variety of fruit trees, and seemed to have been of indirect benefit in checking one of the pernicious scale insects.

It appears that one of the parasites of the scale insect is particularly liable to destruction by ants, and as ants occurred abundantly in all orchards and were constantly on the trees in great numbers,

hese scale destroyers were themselves destroyed by the ants to such in extent as to render them ineffective as aids to the fruit growers. 'Tanglefoot" applied in a continuous band around the trunk formed a barrier which could not be passed by the ants, the scale destroyers were free to develop undisturbed, and this resulted in a marked decrease of pernicious scales with a promise of their total elimination. Reports from growers and inspectors were uniformly to the effect that "Tanglefoot" caused no injury to the banded trees, and correspondence with the Massachusetts users failed to show any case of obvious injury caused by the material.

To put the matter to a direct test in New Jersey, the manufacturers sent me, early in the season, four buckets of "Tanglefoot," which were sent to Horace Roberts, Moorestown, Burlington county; John S. Collins, Moorestown, Burlington county; Henry Pfeiffer, Cologne, Atlantic county, and Joseph H. Black, Son & Company, Hightstown, Mercer county.

To each of these parties a letter was sent explaining the purport of the experiment, and they were asked to make the necessary observations.

Mr. Horace Roberts used the material on apple trees of good size and in bearing condition. When seen by Mr. Dickerson during the summer there was no sign of injury to the trees and no appearance of any beneficial effect as against the scales.

Under date of November 3d, Mr. Roberts wrote that "'Tanglefoot' still sticks to the trees, but I do not see that it hurts them at all. I am unable to tell whether it helps with the scale or not, for the scale is a very rare bird here now."

Mr. John S. Collins reported, October 26th, that he had used the "Tanglefoot" on peach, pear and apple. There was no appearance of injury at that time, and, on the other hand, no apparent benefit had been derived, so far as lessening scale injury is concerned. The material remained sticky enough to prevent insects from crossing it for some time after it was applied, but at the time of the report it had hardened so that it could be readily crossed by any species.

Mr. Henry Pfeiffer reported, under date of November 1st, that on June 1st he had applied the "Tanglefoot" in a band ten inches wide and one-quarter inch thick to one cherry, one apple, one peach, two pear, one quince, one chestnut, one tulip tree and one

oak. June 2d, he applied it similarly to twenty-four young apple trees two years planted, in alternate rows with check rows between.

June 4th, applied to fifty pear trees, partly infested with scale. Size of trees, one to four inches in diameter, with check rows between.

July 5th, all the trees were examined and the material was found in fairly sticky condition. No apparent harm to any tree, but the treated apples had fewer plant lice than the check rows.

August 1st, the trees still showed no trace of injury, but the banding had hardened sufficiently to make it desirable to retouch with additional material. The treated pear trees showed no difference in scale infestation as compared with the checks, but the treated apple trees looked uniformly better, owing to the smaller amount of plant lice infestation.

October 1st, no injury showed on the treated trees, but the scaly specimens were now so badly infested that active measures were necessary, and they were sprayed very soon afterward with whale oil soap suds, at the rate of one pound in two gallons of water. The "Tanglefoot" was retouched where it had hardened.

November 1st, no treated tree of any kind showed injury or benefit from the application. Mr. Pfeiffer states that he will continue the experiment another year.

During the latter part of the season Mr. Dickerson saw the treated trees of the Joseph H. Black & Son farms at Hightstown, and determined that in some cases material injury had been caused. He requested that the subjects be kept under observation and report made later.

October 5th, the following report was made: "The black walnut that was broken by the wind continued to die down as far as the mixture was applied. The mulberry does not seem to be affected in any way. Sweet cherries do not seem to be affected. Paragon chestnut shows an enlargement where the material was applied on a young tree. An American chestnut that was older does not show much effect as yet. Peach trees show two separate effects; one is to soften the bark and change the color of it and on one tree it is plainly destroying the bark. On a plum tree of a European variety we find that it is having practically the same effect as on the peach, and on a prune tree we find that the bark is made brittle, and yet spongy-looking. A quince seems to have been affected the same as the prune. A Japan walnut does not seem

be damaged at all. A pear tree has a trifle of the spongy look the bark, but not so bad as the prune. The large apple tree es not show any effect that would indicate injury. We would ever advise its use on fruit trees, especially those belonging to e rose family. Neither would we think it entirely safe on nut rees."

On the whole, judging from observation and experiment, "Tree Tanglefoot" may be considered safe on all the ordinary shade and orest trees when well out of the sapling stage, and that is more specially true of rough or scaly-barked trees. On smooth-barked rees the danger is greater until they are well grown. On apple trees there seems to be little danger when the trees are well grown, and the same is probably true on pear. On young fruit trees I should be afraid of it, no matter what the variety. It is quite possible that some of the younger apple trees treated by Mr. Pfeiffer may show bark injury on closer examination, and, if none is caused now, it may develop in the course of another year if the application is continued.

As to the field for a sticky banding, that is a large one in cities where the tussock moths are to be dealt with, and it may become a very useful material if it becomes necessary to fight the gypsy or brown-tail moths in New Jersey. The results noted by Mr. Pfeiffer on the apple trees will make necessary a closer observation of the plant lice that feed on the tips to determine what natural checks are operative and how these, in turn, are affected.

REPORT OF THE MOSQUITO INVESTIGATIONS IN 1906.

(611)

Fig. 1.

An interested audience. One of the attendants on collections in town lot pools. *C. pipiens*, *C. sylvestris*, *C. jamaicensis* and *Anopheles* are found in such pools. From an original photo.

REPORT OF THE MOSQUITO INVESTIGATIONS IN 1906.

BY JOHN B. SMITH.

During the fiscal year, November 1st, 1905, to October 31st, 1906, the sum of $3,500 was available for the purpose of continuing work under chapter 80 of the laws of 1905, and the sum of $6,000 was available for the purpose of aiding communities that might wish to take advantage of the provisions of the law. Of the latter sum, $500 were assigned to the city of Elizabeth and $375 to the borough of Atlantic Highlands; the balance was turned back into the treasury.

The writer has been continued as executive officer under the law, and all investigations have been made under his direction. As field assistant especially for marsh work, Mr. H. H. Brehme has been continued, and as field assistant for inland work and to take charge of the laboratory experiments, Mr. John A. Grossbeck has also been retained.

The fish investigations and experiments referred to in the previous report have been concluded by Mr. W. P. Seal, and his record and conclusions form part of this report. Briefly stated, the experiments have not been as successful as was hoped and expected, and it is decidedly questionable whether the top minnow, *Gambusia affinis,* can be made a permanent inhabitant of any of the natural waters of the State, although this does not mean that it may not have a field in artificial waters not stocked with predatory fish.

Each summer offers climatic peculiarities of its own, and that of 1906 was no exception to the rule. After a normal spring and early summer, during which Newark and Elizabeth secured the full benefit of the marsh work by the absence of the flights that in

the past filled those cities in May and June, came a period of almost daily rains. With these rains came also oppressive, sultry, high temperature, and all those factors that make for rapid and prolific breeding of the common house mosquito, *Culex pipiens*. The result was that during all of midsummer this species increased in numbers where ordinarily few if any came to maturity. It was not all a misfortune, however, since it attracted attention to many breeding places that would otherwise have been overlooked and in several places called attention to the necessity for local work. In the reports on special localities these matters are more particularly referred to, and the report on Mount Holly is typical of conditions that exist in many other places in the State.

A direct result of this accumulation of specimens during the latter part of the season is that there are at present writing great numbers of these house mosquitoes hibernating in the cellars in the localities where they were abundant during the summer. These specimens will furnish the start for the season of 1907, and, if left undisturbed, will provide for an abundant early crop if the weather is at all favorable.

It is quite possible to kill off a very large percentage of this hibernating series—all impregnated females—and every specimen killed off means a potential 200 to 400 new crop. In the report for 1904 it was shown that powdered stramonium or "Jimpson Weed" may be used as a fumigant to kill off the dormant specimens, and on a later page the use of the "Culicide" employed at New Orleans in the campaign against the yellow fever mosquitoes is described. Outfits for fumigating with this material are so very cheap that every local board of health could afford a dozen or more to be loaned to those who wish to treat their cellars. In fact, whoever has an alcohol lamp can make the outfit at a cost of ten to fifteen cents, since an eight-inch section of an ordinary stove pipe furnishes the main part of it.

Attention was also directed to the part played by several sylvan or woods mosquitoes, which also were unusually abundant in some of the hilly parts of the State. These species have only a single brood annually, emerging in late April, but some of them live on until midsummer, and are a nuisance in the woodland and on porches of houses surrounded by trees near their haunts. In the account of the investigations made near Short Hills and Millburn and on the shores of Lake Hopatcong, specific reference is made to

these forms and to the methods of dealing with them. The fact that there is only one brood to be dealt with simplifies matters in one direction, but it also makes it necessary to take measures so early, before adult mosquitoes are ordinarily seen about, that there is great danger of slipping by the proper time.

The Staten Island marsh area, which has been referred to in previous reports, has been eliminated as a danger to New Jersey. The New York Department of Health secured an appropriation sufficient to drain all the marshes on that island, under the direction of Dr. Alvah H. Doty, the health officer of the port of New York, and practically no salt marsh mosquitoes can come from that territory in future. The work has been carefully followed throughout the summer by Mr. Brehme, and a more detailed reference follows.

All the preliminary work necessary to a prompt action under chapter 134 of the laws of 1906 has been done, and there seems to be no reason why a large section of the State near the centre of population should not be cleared during the summer of 1907.

The Jersey City Meadow.

The Jersey City Board of Health has in the past manifested a great interest in the problem of ridding the territory within its jurisdiction of mosquito-breeding places, and during the early months of the year matters looked favorable for securing the funds necessary for the drainage of the salt marshes. April 13th, the meadows were therefore carefully examined and the board was advised of exactly what work was to be done, where a beginning should be made to secure the maximum effect early in the summer, and the amount that would be required to do the work with the percentage that would be available from the State appropriation. The expected funds did not become available, however, and nothing was done to carry out the recommendations made.*

June 28th, the meadow was visited and found to contain a small brood of adults, mostly *cantator*, and the fourth of the season, while in the pools young larvæ of brood 5 were present. The marsh was not again visited until August 22d, just after brood 6, the largest of the season, had made its appearance. This was nearly all

* Since writing the above, $2,500 has been appropriated by the city.

cantator, scarcely 1 per cent. of *sollicitans* being apparent. A high tide had just covered the meadows and left matters in excellent shape for brood 7. Brood 6 migrated north, up the valley of the Hackensack to New Durham, where only a few examples were found, and up the valley of the Passaic to the mountains near Paterson, where they were taken in great abundance. The bulk of the brood remained at Arlington, however, and mosquitoes were very plentiful there on August 21st.

Hot, sultry weather favored brood 7, and it was on the wing August 30th, only from ten to twelve days after brood 6. There were about 70 per cent. *cantator* to 30 per cent. *sollicitans*, and the prevailing southwest wind carried almost the whole output into Jersey City.

Brood 8 was much smaller and was found on the wing September 17th in the proportion of 60 per cent. *cantator* to 40 per cent. *sollicitans*. Its flight was not traced nor was the meadow again inspected prior to November 1st.

Newark.

Newark and its vicinity has been kept under close observation for several reasons. *First*, it is matter of very great importance that the work of the ditches should be watched to note what deterioration, if any, takes place, whether there is any impairment of effectiveness and whether they are sufficient in size and number to meet the requirement of the seasons as they vary from year to year; *second*, encroachments upon the marshes are made each year by the growing city and careless interference with the drainage scheme might easily change a safe area to a mosquito breeder; *third*, the city of Newark maintains an inspector on the marshes throughout the season, and it was desired to make use of his observations on the habits of marsh species; *fourth*, it was desired to determine the location of the local breeding places and to assist the local authorities in their efforts to lessen the pest.

The general results were that the city of Newark was almost totally free from salt marsh mosquitoes during the early part of the summer, and later only a few were found from the Elizabeth or Jersey City marshes. The frequent rains and hot, sultry weather during a portion of the summer was unusually favorable to the

development of the common house mosquito, *Culex pipiens,* and this was present in altogether unusual abundance late in summer.

The whole matter was in the hands of Mr. Brehme, and he reports a total of twenty-nine inspections during the season with the following results:

January 11th, investigated the work in progress at Bound creek to learn whether the dredgers were interfering with the drainage. Found that ditches had been dug outside the embankment limiting the area to be filled and no interference.

April 6th, found a new railroad embankment being run across the Hamburg Place section of the meadow without regard to the drainage scheme, blocking ditches and interrupting the course of a creek, which threatened to turn a safe meadow into a bog hole. The board of health was notified, and they, in turn, served the offending railroad company with notice to restore drainage. This order was eventually complied with, as inspections made April 21st and 26th determined.

April 27th, an investigation was made as to the effect of some dumping operations on one of the drained sections, and it was found that this, too, was being done without regard to the drainage. The contractors were ordered to cease dumping and a new outlet was established into the bay, so that live water was admitted into the ditches. Up to this time the meadow was in good condition everywhere, and no mosquito breeding was going on anywhere.

May 7th, the Bloomfield avenue area was inspected. This in previous years had been a breeding place for a number of the spring species, but was now so densely overgrown that only a few insignificant pools remained, and in these only a few *C. canadensis* larvæ were found.

May 14th, an evening tour was made to determine whether any specimens from the salt marshes were to be found. Only isolated examples could be found, where in previous years, at the same season, they could be swept up by the quart, in stores.

May 16th, the lower section of the city was inspected for the board of health, to determine whether a suspected area was a breeding place for salt marsh species. The area was found to be a fresh-water swamp section, without indication of present mosquito danger.

Night inspections were continued May 16th and 17th, and only isolated examples of *cantator* were seen. People were sitting out everywhere, in comfort, and no one was fighting mosquitoes.

May 26th, the marsh was found dry, free from mosquito-breeding places, and even on the Ebeling tract Mr. Erhard had little trouble in killing off the small brood that hatched there. Then came a two-days rain, measuring 3.16 inches, and the marsh was again examined May 29th. Everything was covered with water, but the ditches were working properly, and on the 31st all the water was gone except in a few places, where so little remained that its disappearance was a matter of hours only.

There was a very high tide June 12th, and on the 13th it was found that the Hamburg Place area had been covered, bringing up "killies" everywhere; the ditches were working properly and Mr. Erhard was removing such driftage as was likely to obstruct the free outflow of water. All the other areas were already drained clear and no pools remained.

June 18th, a city inspection was made over areas where *pipiens* had been known to breed and it was found that the local board had done good work, oiling some places and filling others with earth or ashes, so as to dispose of them finally.

A period of high tides being in progress, the meadow was visited June 19th, and found to be water-soaked, with all depressings full of water, only a few of them with "killies." June 24th, the meadow was again dry except on the Ebeling tract, on which there was quite some water containing scattering larvæ. A few of these developed into adults before the water was all off, but none developed elsewhere on the meadow.

June 27th, the Bloomfield area was again visited and eighteen larvæ were found after the closest kind of collecting. These were *C. territans*, 12; *C. sylvestris*, 3; *Psorophora ciliata*, 1; *Anopheles sp.*, 2. An inspection of Branch Brook Park was made during the same day and larvæ were found in some of the catch basins. The secretary of the commission was notified and thereafter these places were regularly oiled and no breeding was permitted.

July 3d, the fourth marsh brood was on the undrained meadows and the Newark areas were visited to see to what extent it was represented. Only on the Ebeling tract was any breeding going on, and even that was so scattering that little could be determined.

as estimated that 75 per cent. of the insects were *cantator* and er cent. were *sollicitans*. A month later no breeding was found where on the meadow.

.ugust 12th, an inspection was made in the southwestern part of city to locate breeding places of *C. pipiens*, and several cellars ouses in course of erection were found filled with water and rming with larvæ and pupæ. This had been cured on the 24th, the filling of pools and similar places was continued.

August 25th, no breeding was found in any of the public parks l in Branch Brook only a few *cantator* were discovered, obvily migrants from the Jersey City meadows on a northeast wind several days' duration.

August 29th, the marshes were dry and safe, except on the eling tract, where a few larvæ were found, and even there thing was found September 18th. On the 19th a tour of the y showed that the board of health inspectors were still running wn and eliminating local breeding places and that conditions re everywhere better than ever before.

September 22d, the first high tide of the fall came in and the eadows, which were dry in the morning, were completely flooded on after noon, but with the flood came the "killies" in shoals to ke care of any larvæ that might hatch.

October 1st, it was found that another railroad spur was being ilt without regard to drainage; the matter was reported by Mr. rhard, and the company, in response to orders from the board, ilt a culvert that preserved the drainage. On the 6th the meadow as in good condition, but it was found that near the boat-houses long the bay shore barrels and boats containing water were swarmig with larvæ of *C. pipiens*.

The marsh drainage work has stood the test of a very severe eason perfectly, and Newark was freer of marsh mosquitoes than ver before.

Some sections of the city remained practically free from mosquioes until late in the season, while others were severely infested, ut in those cases it was the local breeder *pipiens* that was in fault, nd the board of health did excellent work in locating and abolishng places that in ordinary seasons would not be dangerous, and re now finally done away with. It was also practically demonstrated that boards of health have ample power to enforce their

orders concerning the preservation of drainage even against railroads. After a few prosecutions for interfering with ditches, haymakers on the meadows have found it advisable to bridge them wherever it is necessary to drive across.

Elizabeth.

Fewer mosquitoes hatched from the Elizabeth meadows than in any previous years, and that is largely due to the drainage work done under the direction of the board of health of that city during the two or three years last past. Elizabeth took advantage of the State law and secured in 1905 $500 of State aid by an appropriation of $2,000, and in 1906 nearly the same amount by an appropriation of $1,500. In addition, the Central Railroad of New Jersey contributed the sum of $1,000 in return for certain desired concessions, so that altogether about $5,500 have been expended. Previously, and indeed this was the first marsh work in the State, ditching had been done along the Elizabeth river, so that a great deal of the worst mosquito-breeding territory has been completely eliminated. At the present writing a large section of the marsh area east of the Newark branch of the Central railroad, nearest to Elizabethport, is completely drained. Great ditch has been cleaned and deepened where needed; a wide, deep ditch has cut off angles, and a connection with a branch of Woodruff creek has established a tidewater circulation which replaces the former stagnant condition. Two tide-gates, now in process of building, will prevent future overflow of the southwestern part of the meadow, and will lower the water level materially during the ensuing winter.

Mr. Brehme's reports show that he made twenty-three visits to the meadows during the season, and he states that brood after brood was killed off on the drained area, materially lessening the output of the meadow as a whole. The surface was covered with eggs, and whenever tide or heavy rains filled the depressions, larvæ appeared, lived for a day or two, and then by the millions their bodies covered the surface of the dried-off soil.

The first trip was made April 19th, with Mr. Louis J. Richards, the health inspector of the city, to determine the amount of work that still remained to be done on the Elizabeth river section.

rvæ of the first brood were then observed, but no especial notes re made as to kinds or proportions.

May 10th and 11th were spent in laying out the ditch system th Mr. Richards, and a very large number of larvæ and pupæ, ming brood 2, was observed. This brood hatched about May th, and was followed along the Elizabeth river, through Eliza-th, Aldene, Salem, Union, Springfield and Maplewood, which it iched May 21st. The brood may have reached Summit and ex-ided even further inland, but was not followed beyond the First ountains. It was *cantator* almost entirely.

June 1st, after a period of low tides, many pools were dry on en the undrained meadow, and a large portion of brood No. 3, hich was then in the first larval stage, was killed off. The entire ght was passed on the meadow with Mr. Erhard, and 278 mos-iitoes—130 *cantator*, 148 *sollicitans*—were captured biting. The oject was to determine the question of the hours at which the isects were most active, and the following table shows that clearly. ll the specimens were those attacking Mr. Brehme only, and the act that there were so few shows in itself how much better condi-ions were than in past years, when counting would have been im-ossible. The night, it should be said, was warm and without vind:

Between the hours—	*Cantator.*	*Sollicitans.*
5–6 P. M.	16	9
6–7 "	23	19
7–8 "	30	27
8–9 "	13	14
9–10 "	5	7
10–11 "	1	1
11–12 "	2	..
12–1 A. M.	1	..
1–2 "	2	..
2–3 "	..	2
3–4 "	1	3
4–5 "	14	20
5–6 "	22	46
	130	148

It appears, therefore, that as between the two, *sollicitans* seems to have a period of rest during the middle of the night, but is much more active than *cantator* in the morning hours. And the propor-

tion is greater than shown by the figures, because the actual number of *cantator* on the meadow was as about 8 to 2 of *sollicitans*.

The advance guard of brood 3 emerged June 10th and 11th and left the meadow almost immediately. A few were seen in southwestern Newark on the 13th and some of them got as far as Irvington, which seems to have been their migration limit. A high tide on the 12th flooded the meadows and brought up "killies" enough to wipe out fully half of the full-grown larvæ and pupæ that remained in the pools. What remained was on the wing on the 20th and this section reached Short Hills and the South Mountain Reservation June 25th, when nine *cantator* and five *sollicitans* were taken there. Newly-hatched larvæ of the fourth brood were found June 24th, on the 29th they were nearly fully developed and a few pupæ had formed, and on July 3d the adults were on the wing. They moved inland slowly and reached Short Hills about July 12th. Twenty-one specimens were captured there on the 14th. *Cantator* and *sollicitans* were almost equally represented in this brood. Brood 5 was another small one and was found on the meadow, becoming adult between July 25th and 28th. It was about 80 per cent. *cantator* to 20 per cent. *sollicitans*, and did not get inland further than Irvington.

August 10th, the meadow was in normal condition, the drained area with only a few odd pools containing larvæ, the rest with larvæ of brood 6 full grown and pupating. August 13th this brood hatched, 85 per cent. *sollicitans* to 15 per cent. *cantator*, and left the meadow almost immediately. Before the meadow was reached from North Elizabeth hundreds of *sollicitans* were encountered, while on the meadow itself comparatively small numbers only remained. This was a large brood and easily followed through every town well into Summit, where a goodly number was taken July 18th. This brood traveled almost directly west, and the towns north of Irvington, Maplewood and Millburn got only single specimens, while Irvington, Springfield, Millburn, Short Hills and Summit got a full supply. The city of Elizabeth got its first notable supply from brood 6, and fully 90 per cent. of this brood left the meadow, which, for a time, was much freer from mosquitoes than the neighboring highland.

August 23d, the work of relieving Great ditch was well advanced, and 1,650 feet of ditch six feet wide and five feet deep has

been completed by Mr. Richards. There was plenty of water on the undrained meadow and young larvæ of brood 7 were in evidence. Five days later it was seen that cleaning and relieving Great ditch had helped the meadow greatly and had taken off many tons of water. Brood 7 was nearing the pupal stage and promised to be much smaller than 6. It matured August 31st, was 65 per cent. *sollicitans* to 35 per cent. *cantator*, and did not seem inclined to migrate. Fully 90 per cent. remained in the meadow and the balance did not get further west than North Elizabeth.

September 8th, the work of clearing Great ditch and cutting the new ditch to connect with Woodruff creek was making good headway and another brood of larvæ was found in the pools, the eighth of the season. The meadow was in a normal condition, *i. e.*, on the undrained portion about 75 per cent. of the depressions contained water and about half of these were filled with wrigglers, the balance containing "killies." A week later brood 8 was nearly mature, but had been much reduced by the drying out of pools. September 18th it was on the wing, 70 per cent. *sollicitans* to 30 per cent. *cantator*. Most of these remained on the marshes and few got further inland than North Elizabeth.

September 27th, brood 9 was found to be well advanced, and on October 2d it was on the wing, a very small one, because the high tide of September 22d had brought in "killies" enough to clean out every infested pool that was reached. Ninety per cent. of these insects were *sollicitans*, 9 per cent. were *cantator* and 1 per cent. was *salinarius*, the first appearance of this species for the season in appreciable numbers. This was another stay-at-home brood, and did not extend beyond North Elizabeth.

October 12th, a series of low tides had left the meadow very dry, and in the remaining pools young larvæ of brood 10 were found. This brood was almost completely destroyed by the high tides, which brought fish to almost every pool on the meadow. It was the last brood that could be enumerated, because later only isolated pools with wrigglers were found.

October 19th, the last regular inspection was made, the work of cleaning Great ditch, the railroad ditch, and cutting the connecting ditch to Woodruff creek was nearly completed, and actual completion was awaiting money enough to do the work. On the whole, what was done is completed in the best possible manner,

and things are in excellent shape for a completion of the drainage scheme under the new law.

Several city inspections were made to find local breeding places, and quite a number of these were found and reported to Mr. Richards, who took prompt action upon them.

The Linden Marshes.

The territory between the Elizabeth City line and the Rahway river, and south of it to Carteret, have been roughly called the Linden meadows, because most of the area lies within the township of that name. It is one of the most virulent breeding places in the district north of Sandy Hook, and from it the migrations extend up the valleys of the Elizabeth and Rahway rivers, but principally up the latter, to the second range of the Orange mountains. It supplements the crop of the Elizabeth meadows and the swarms spread out along the tributaries of the Rahway to Plainfield, Scotch Plains and that general territory. There is no other area as important in its effects on the settlements near the gap in the mountains through which the Rahway river flows, and for that reason several inspections were made during the summer, and a drainage scheme was worked out, to be carried out during the season of 1907, if possible.

The first inspection, made June 6th, when brood No. 3 was in the pools and some eight hundred larvæ were taken to determine the species. All proved to be *sollicitans*, and, because a great many of the breeding pools had a stock of "killies," the brood was not a very large one.

July 6th, brood No. 4 was on the wing, and this, consisting of 80 per cent. *sollicitans* to 20 per cent. *cantator*, was traced to Short Hills.

Beginning July 12th, the actual survey of the meadow and preparation of the drainage plan was commenced, and continued, with interruptions, to July 24th, when it was completed to Port Reading. The whole marsh area was surveyed and plotted out irrespective of township lines, though in such manner as to make it possible to estimate on each section by itself.

During the last days of August brood No. 7 came to maturity, and on September 5th adults were on the meadow in countless

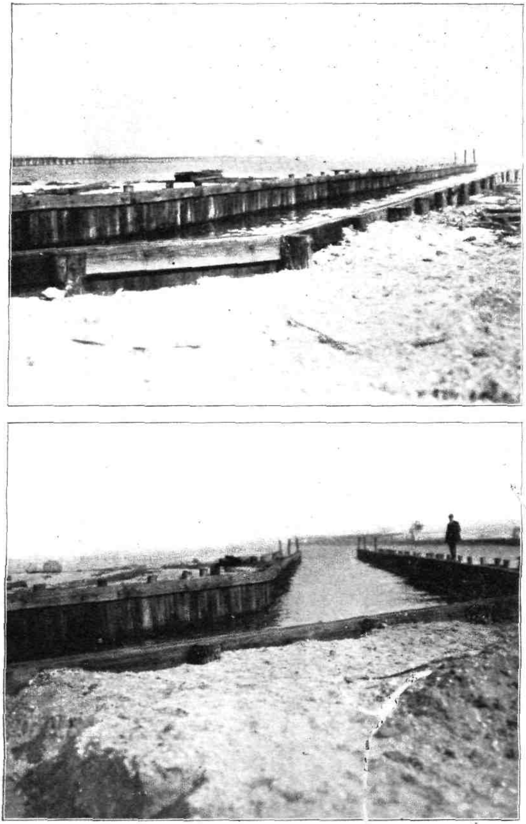


Fig. 2.

Atlantic Highlands. Two views of the Bulkhead at the mouth of Manymind Creek to prevent

numbers, almost exclusively *sollicitans*, *C. cantator* being represented by straggling specimens only. This was the largest brood of the season and almost all its members remained on the meadow. There was a little invasion of the adjacent high land, but no real migration.

Atlantic Highlands.

The borough of Atlantic Highlands has within its limits a narrow, winding stream—Many-mind creek—which empties into Raritan bay, and which has been subject to changes in course at its mouth through winter storms and by the action of the waves. On both sides of this stream is an area of low marsh land, frequently covered by the tides, and which was an ideal breeding place for mosquitoes. Whenever the waves had filled or obstructed the mouth of the creek this area would fill up and remain filled until a heavy rain or the accumulation from above would be sufficient to enable the stream to force its way through the obstruction and open up its mouth to the bay.

A drainage commission appointed under the law had expended a considerable sum in improving conditions, had deepened and cleaned out the creek, and had begun the construction of a bulkhead to protect the mouth of the creek. Application was made for assistance from the State fund, and about the middle of June a preliminary survey was made. There was some question as to just what method of improvement was best adapted to the local conditions, but after some conferences it was decided that ditching would hold if properly placed, and the contract for drainage was awarded, the work to be approved by the surveyor for the commission and Mr. Brehme. It was not until late in September that the work was finally begun after the ditches had been staked out by Mr. Brehme, but they were completed and certified in satisfactory condition on October 13th. A bulkhead extending out some two hundred and fifty feet through the surf has also been erected, and will, it is believed, be sufficient to protect the mouth of the creek from further impairment by the sea. On November 5th I went over the ground with Mr. Brehme and the contractor, and the result seems to be satisfactory. In some places the ditches run through a sandy streak, and must be sloped and looked after, but there seems to be no reason why, with reasonable care, the drainage

system should not be maintained and this marsh area kept free from breeding places in the future. The sum of $375 was certified from the fund appropriated under the law of 1905 to assist in the completion of this work.

Shrewsbury River Area.

An account of the work done at Monmouth Beach and other points along the Shrewsbury river has been given in previous reports, and the entire region to Long Branch has been kept under more or less constant observation during the summer by Mr. Brehme. The area at Port-au-Peck had not been included in the work done in previous years, and proved a source of annoyance to the residents of the region that had already been drained. So well convinced were these that the drainage work was a success for the purpose for which it was intended that they raised money by subscription to get rid of the last breeding area within their jurisdiction. This Port-au-Peck marsh had been in the market for some time, but an intending purchaser had incautiously been taken upon it in a mosquito season, and his intentions changed straightway. The character of the drainage required was determined by Mr. Brehme and reported upon, and work was begun early in April, when the first brood of larvæ had just made its appearance. The work was laid out so as to get through the worst breeding sections first, and the main ditches were so placed as to run off the greatest possible amount of surface water in the least possible time. Examinations were made April 17th and 27th, and again on May 2d, when the work was found to be completed, and a certificate to that effect was given the contractor. Not a specimen of this brood was allowed to get on the wing.

June 17th the whole marsh area was found to be in excellent condition and not a marsh mosquito was found, but some *C. pipiens* had been bred in gutters and cesspools, and these were in evidence. July 5th, marsh conditions continued to be good, but town conditions were worse. The surface water due to rains had not been kept down, and *C. pipiens* was becoming more numerous. On August 7th matters had become so much worse that a systematic inspection was made, the breeding pools and gutters were enumerated and located, and a report was made to the Monmouth Beach Protective Association. This report was later referred to the board of health and acted upon.

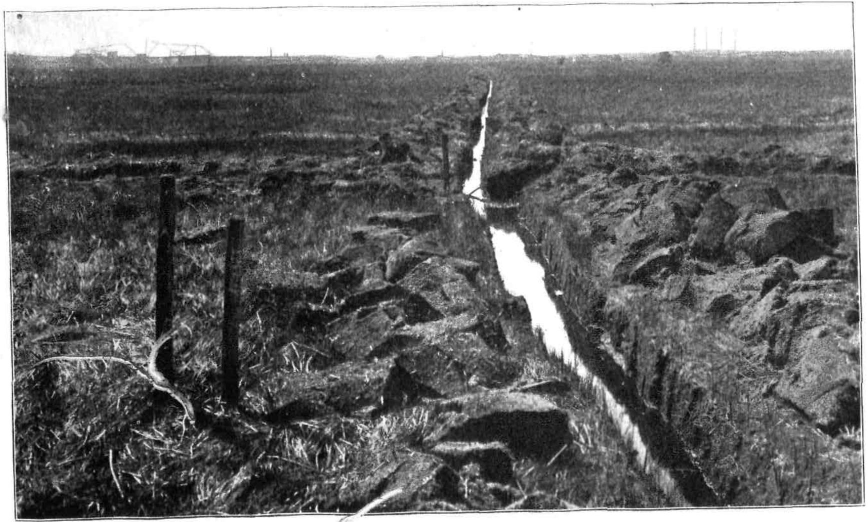


Fig. 6.

... showing the huge sods taken out by the machine on the Staten Island Marshes. From a photo made for Dr. A. H. Doty.

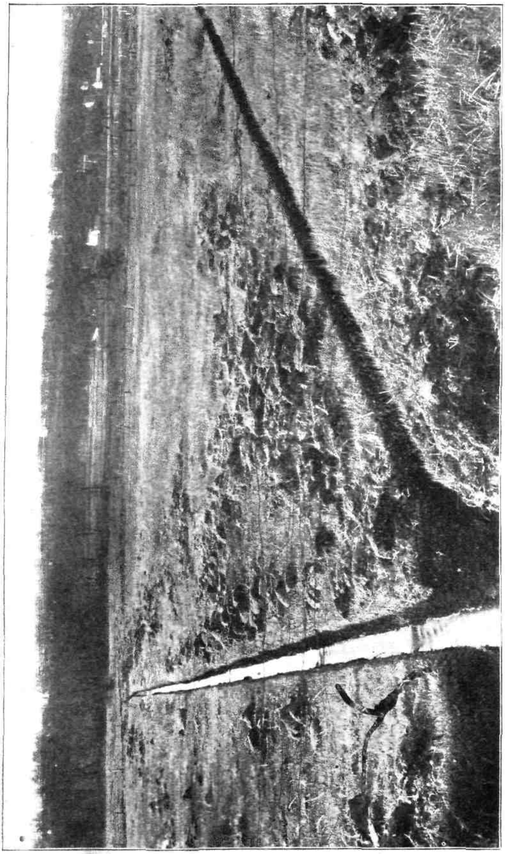


Fig. 4.

August 8th, the Rumson Neck area was looked over and the marsh was found in good condition. On the upland some *C. pipiens* were breeding, but they were not numerous at this time. The Port-au-Peck property had been sold since it was drained and tents were now found on it to shelter camping parties. A year ago it was almost impossible to get on the meadow at all without gum boots, and no camping party would have maintained itself twenty-four hours, if, indeed, it persisted long enough to pitch its tents properly. It was learned that some hundred houses had been planned for at this point, increasing property values many hundred per cent., all because the marsh mosquitoes had been eliminated.

At North Long Branch, which has a small salt marsh area which is not yet drained, some *C. sollicitans* were found August 9th, and there were also some *C. pipiens* that were town bred. At Long Branch proper only the local *C. pipiens* was found.

September 1st and 3d the final inspection of the marsh areas was made and no breeding was found. The drainage scheme works perfectly, and so far as could be discovered not a single marsh mosquito developed, where untold millions emerged in years gone by. The entire area is kept in order by one man with a motor boat who gets from one point to another, patrols the ditches to see that there is no interference and removes any obstructions that may be brought in by tides or the wash from waves caused by steamers or otherwise.

Whatever mosquitoes were found in this region were bred in neglected gutters, lot pools, cesspools and other stagnant water areas. After attention had been called to it matters improved, and on September 1st the clogged gutters were found opened, many pools had been filled or graded and other places had been oiled. It will not do even for communities that have destroyed the marsh species to neglect the conditions that favor the development of *pipiens* in a season like that of 1906.

STATEN ISLAND.

The work done on Staten Island has been kept under constant observation because of its bearing upon the effectiveness of the work to be done in New Jersey. The Arthur Kill, which separates the island from the New Jersey mainland, is so narrow that it

forms no sort of bar to the flight of the salt marsh mosquitoes from one side to the other. Until Staten Island conditions were improved, the New Jersey communities from Newark to Perth Amboy and further inland would be subject to periodical invasions, and, on the other hand, the Staten Island communities cannot get the full benefit of their work until the New Jersey marshes between the same points are cleaned up.

Efforts were therefore made from the beginning to secure the co-operation of the New York authorities, and the New York Department of Health, mainly through the influence of Dr. Alvah H. Doty, has accepted in full the general plan of extermination advocated in New Jersey. Dr. Doty had made a study of the subject as it manifested itself on Staten Island, and had, independently, reached much the same conclusions as the writer. Consequently he was quite ready to accept responsibility for carrying out the plans suggested for Staten Island, and a survey of the marsh area was made at his request, upon which an estimate of probable cost was made which resulted in an appropriation for the work by the City of New York.

The general plan of this work is much like that followed for the Newark and Elizabeth marshes, and it involved the entire island. Work was started in the fall of 1905 and completed on the east and south shore before the opening of the spring of 1906. On the western shore the work has been continued throughout the summer and is now (November) practically completed. The object has been to drain off all surface water so as to prevent mosquito breeding, and that work has been an unqualified success. For the entire season the Midland and South Beach shore resorts have been practically free from mosquitoes and have prospered beyond all measure. Where, in previous years, approaching dusk heralded a homeward movement because the mosquito pest became simply unendurable, during the past season the evenings were the most enjoyable periods of the days. Putting up the screens was postponed from time to time until the summer was gone, and it was realized that there had been a real revolution. Where, in past seasons porches were used only when carefully screened in, these screened-in areas were not used at all. The members of the Country Club and frequenters of the golf links derived the full benefit of the improvement, and while no body of men had been more

sceptical as to results, they are now convinced and even enthusiastic. The direct results of the work have been: improvement in the meadow conditions, so that they now grow good salt hay, which can be harvested safely and easily, where there were only bog morasses with useless grasses before; increase in land values, due to its becoming more desirable for residential purposes; increased prosperity of the shore resorts and the consequent addition of new and much greater amusement enterprises; the utilization of some of the drained areas for industrial establishments employing an aggregate of nearly ten thousand men.

It would be absurd to say that there were no mosquitoes at all on Staten Island during the summer, for the season was a trying one and *pipiens* bred wherever there was a chance for it. But it was a test of the effectiveness of the drainage scheme under the most trying conditions, and it stood the test perfectly; practically no salt marsh species developed on the drained areas.

But Dr. Doty took advantage of the season to locate the breeding places for the inland species, for wherever standing water could exist it existed this year, and an enormous improvement has been made in this direction, the benefit from which will be apparent in 1907.

Altogether, Staten Island may serve as an object lesson, and the work done there has been suggestive in many ways that will be useful in the New Jersey work, besides removing the danger to our citizens to which reference has been previously made.

In the New York "Globe," for November 14th, 1906, is a fair statement of what has been accomplished and of the benefits derived by the community. Dr. Doty informs me that the total area drained is twenty square miles and that about 400 miles of ditches have been actually dug. A large percentage of this ditching was done with the True ditcher, illustrated in earlier reports, and these ditches are nine inches wide and twenty-four inches deep.

Arlington.

Three inspections were made during the season to ascertain whether local breeding places existed and what particular species were troublesome. The first of these, made May 25th, showed

matters in good condition, no breeding places obvious and no mosquitoes flying.

July 10th, a few specimens of the salt marsh species were found, but no locals and no active breeding places. Some of the danger points where breeding had been found in previous years were in process of elimination by filling and grading.

August 21st, both the salt marsh species were present in large numbers, though *cantator* outnumbered *sollicitans* ten to one. This was the flight of brood 6 from the Jersey City meadow, and filled all parts of the town. No breeding places were found in the wooded area, nor indeed elsewhere in the public places in the town limits.

Point-No-Point.

This is the triangular body of land at the junction of the Hackensack and Passaic rivers where they enter Newark bay, and it extends north to the main line of the Pennsylvania railroad. It was, when the mosquito investigation was first begun, one of the worst breeding places in the State and the source of an unlimited supply to the surrounding territory. Its position is such that migrating swarms could reach Jersey City, Newark, Elizabeth and the valleys of both Hackensack and Passaic with equal facility, and no more objectionable spot existed.

Three years ago the Hackensack Meadows Company began covering over this area with sand by means of hydraulic dredges, and Mr. Brehme reports: "While the entire meadow is not yet filled, enough sand is flooded over it to fill the blind ditches and breeding pools. Six thorough inspections were made during the season and not one mosquito larva was found." As a breeding place this area is no longer of importance, and it forms an important link in the chain of work needed to eliminate the mosquito pest from the most densely populated section of the State.

East Orange.

At the request of and in company with Mr. Roger H. Butterworth, president of the local board of health, Mr. Grossbeck in June examined a number of localities suspected as mosquito breeders. Some low open meadow areas with tussocks and long

ass patches looked bad, but turned out nothing worse than a few . *territans* larvæ. A swampy area around the works of the range Water Company, caused by an overflow from disused wells, as found more dangerous, larvæ of *Culex territans* and *pipiens* curring in some numbers, while associated with *territans* the rvæ of *Anopheles* were also found in such numbers as to indicate at they probably occurred throughout the entire area.

As this was early for *Anopheles*, the indications were that later ı the season matters would become much worse, especially if rains rovided additional water. The water company had been served ith a notice to drain the land, but had paid no attention to it, but he discovery of the actual presence of *Anopheles* larvæ so clearly rought the area under the ban of the health laws that a threat rom the board to act at the expense of the water company resulted n the immediate improvement of the danger area.

The worst place found was a ditch almost a mile in length, partly open and in places almost stagnant, into which a large amount of surface water, etc., is drained. East Orange has the separate system of sewers, which receives no surface water, and many cellars and the like are connected with drains that empty into this ditch. While it is not, therefore, really an open sewer, it comes very near to it. Along the stagnant and slow-moving areas half-grown larvæ of *C. pipiens* were dipped up in such numbers that each glassful contained hundreds. Adults were plentiful along the margins, and on the surface an average of at least one egg-boat a foot could be seen. It is obvious that this one ditch alone could produce a fair-sized infestation for the entire municipality, and the governing body was notified, oil being applied as an immediate remedy for existing conditions.

This is one of those cases that needs constant watching. At present it seems impossible to do without the ditch; there is not much fall to the outlet and stagnation cannot be altogether prevented, even with the best looking after. But whenever clogging is permitted by the growth of vegetation or otherwise, a veritable mosquito mill is established which must receive periodical oil applications to keep it in measurably safe condition. No *Anopheles* larvæ were found, and perhaps none are apt to develop there.

Mr. Butterworth informed me that after his notice the city authorities improved matters somewhat, but they could not give

permanent relief by closing the ditch or putting a pipe in its place. It is realized that the place needs watching, and such conditions occur in many places, giving rise to local infestations complained of.

Orange Mountain Towns.

The towns and villages along the range of the Orange or Watchung mountains are fast increasing in size, wealth and population, and are in every respect desirable as places of residence. Unfortunately they suffer at times from the mosquito pest, and South Orange was among the first, if not actually the first, municipality in the State to consider the question and to attempt to secure relief by local work. No other community has done so much really satisfactory work as South Orange has done under the leadership of Mr. Spencer Miller, and few settlements are so free from local breeding places. The experience gained in that work may well serve as an aid to other bodies, and to some extent the example has been followed in the neighborhood. But in the course of the work it developed that local action, important as it was and effective as it proved, could not be alone relied upon. Mosquitoes came in from other places, and the idea that a hundred feet or even yards was the limit of flight of an adult mosquito was definitely exploded.

So much appeared in publications of various kinds on the mosquito subject that a number of other communities along this same ridge have inquired as to what could be done for their relief. This induced me to provide for a series of collections and inspections extending through the South Mountain Reservation, Maplewood, Springfield, Millburn, Short Hills and Summit, to determine just what kind of mosquitoes were offensive and just where they bred.

Mr. Brehme and Mr. Grossbeck were both assigned to the work and separately and together went over the ground from time to time, Mr. Brehme in his task of following the migrations from the salt marshes, Mr. Grossbeck to locate the woodland areas. To determine the species actually troublesome on porches and in gardens, Mr. Wm. W. Renwick, of Millburn, was good enough to send in examples at intervals throughout the season.

The first trip was made April 20th and 21st over the South Mountain Reservation, and larvæ were collected in small numbers

roughout the woodland pools. There was not a great deal of ater anywhere at this time and no mosquitoes were on the wing. f the larvæ sent in all save two or three proved to be *Culex canaensis.* The exceptions were a specimen or two of *C. abserratus* nd one of *C. abfitchii-siphonalis.* *C. canadensis* is always the ommon woods mosquito of early spring, bites freely but not iciously, is easily scared off, rarely ventures outside the woods, ever enters houses, but does occasionally get on porches where ey are well shaded by trees. Its life is short as a rule, and while here seem to be fractional broods later in the season the mosuitoes are so rarely seen that they are scarcely to be ranked as estiferous. Until the present year the other species were so rare hat we had only a few examples in the collection and both have een recognized as species only within two years.

April 22d and 23d it rained, a soaking spring rain that left nuch water on the ground, and on the 24th Mr. Brehme made nother collection over the same general area, taking 334 larvæ, nostly of recent hatching. Most of these also proved to be *C. canalensis,* but there were a few *abserratus* and *abfitchii.* A collection nade on April 28th showed the same characteristics.

May 2d, thirteen adult mosquitoes were sent in from Millburn, nd of these twelve were *C. cantator* or salt marsh migrants and ne was *C. abfitchii.* On the same day Mr. Grossbeck went hrough Millburn township with specific instructions to investigate the "keetle" or "pot holes" between the wooded knolls or hillocks. These pot holes are very numerous, as the country is very irregular, and they vary in size from a puddle to a pool one hundred feet in diameter: sometimes so shallow as to hold water for a brief period only in early spring; in a few cases so deep as to be practically permanent: sometimes without vegetation or insect life other than mosquito wrigglers: sometimes with aquatic life in considerable variety—mosquitoes being then, as a rule, absent. In some of these pools wrigglers occurred in considerable numbers, and here *C. abfitchii* was in greater abundance than we had ever known it before—much more plentiful than *C. canadensis,* which was but sparsely represented. Several swampy woodland areas were examined and no wrigglers of any kind were found; predatory aquatic life occurred in abundance and wrigglers simply could not live here. A part of this area is overgrown with skunk cabbages,

and we have never found wrigglers in such places. So, also, there is a considerable black mud, swampy area between Morris turnpike, Millburn avenue and Short Hills road, which looks nasty, but where absolutely no wrigglers were found and where none were found at any time later in the season.

In the southeastern portion of the township is a large, low area, mostly dry, at time of examination, but with a series of badly-arranged ditches, which had no proper outlet. In these ditches puddles had formed and many of these were swarming with larvæ of *C. sylvestris*. So at the sides of the road were a number of pools, and some of these contained larvæ of the same species. Practically no large danger areas were found and the bulk of the mosquito life in the township was developing in the pot holes.

As to the *Culex sylvestris* found breeding in the ditches and along the roadsides, this favors open waters and swampy areas, and rarely gets into real woodland pools. It does get under the trees, in some cases, but rarely occurs in pot holes. It has a succession of broods throughout the season, is not a vicious biter, flies for a considerable distance and gets freely on porches, though rarely into houses.

May 17th, the territory between South Orange and Millburn was covered by Mr. Brehme, who found the pools pretty well dried out; took no larvæ and less than twenty adult mosquitoes, all of them woods species, not definitely determined.

May 22d, twelve adults were received from Short Hills, and all were *abfitchii*.

May 27th, Mr. Grossbeck and Mr. Brehme drove over this area together after a day and night of heavy rain. This had refilled the dried-out depressions and had added to those that yet contained water, but in only one place were wrigglers found. This was in a pool that had turned foul before the rain and contained one specimen of *Anopheles* and a number of the predatory *Corethra* larvæ—producing the short-beaked mosquitoes that cannot bite. As for adults, there were plenty of them. On the streets, in all the roads, on the porches, in the hotels—all *C. cantator*, and hundreds of them. They simply covered the horse while driving along the Rahway river. This was a salt marsh migration from the Linden marsh, where brood 2 was on the wing, about May 21st, and proved to demonstration the necessity for the marsh work before the local work could be expected to count. Mr.

rossbeck suggests in his report: "A dozen others [*cantator*] ere taken on the weather-boards under a porch on Springfield venue. *It is worthy of note that this dwelling was close to the* oot where *C. sylvestris* was found breeding on May 3d, and that o specimens of this species were seen at this time. In no instance as any species other than *C. cantator* seen in the roadways or on ouses where we looked.

"On the other hand, when we got into the woods, *cantator* dis- ppeared and *siphonalis* [*abfitchii*] was common, and bit raven- usly. *C. siphonalis* is scarcely to be distinguished from *cantans* n the adult stage and not at all when they are even slightly flown; ut since the larvæ of the former species were common here May d, *it is safe to say that this is the species we now encountered.*" Two examples of *C. pretans* were also taken.

June 3d, a box of specimens said to have been captured on the South Mountain Reservation were sent in by Mr. Renwick with he statement that "mosquitoes were very hungry in the reserva- ion." These were twenty *abfitchii* and four *cantator*. These are he two species found by Mr. Grossbeck a few day previously, and he sending indicates a woods rather than a road capture.

June 5th, Mr. Brehme again covered the territory from South nountain to Millburn, taking no adults on the way, but turning ut a few larvæ between Short Hills road and the cemetery. These vere found to be half-grown *C. sylvestris* and a few *C. trivittatus.* Later in the day, on the South Mountain Reservation, twenty-three dults were taken, twenty *cantator* and three *sollicitans*, the latter *making its first appearance in the marsh migrations.*

June 11th, on the South Mountain Reservation all the pools were dried out, but 118 adults were collected, of which 117 were *cantator* and one was *canadensis*. At Millburn and Short Hills breeding conditions were very similar, and as the wind was blowing briskly no adults were found flying.

June 14th, Messrs. Brehme and Grossbeck again covered the ground together and found absolutely no local breeding in progress. In the bright sunny roadways no mosquitos were found. In the swampy woodland area between Millburn avenue, Morris turnpike and Short Hills road mosquitoes were present in great numbers, *and with few exceptions they were cantator*, the salt-marsh species; the exceptions were either *cantans* or *abfitchii*, probably the latter.

In the pot-hole area, though many of the holes held water, n breeding was in progress, but adults were present in great nun bers. *Cantans* or *abfitchii* were most abundant in the ratio of te to one *cantator*, and all were vicious in the attack. A few *sylve. tris* were also seen, but these were timid and more frequentl alighted on the clothing than on exposed portions of the body. I all cases they were very slow in biting, in marked contrast to the *cantans*.

June 25th, Mr. Brehme again collected over this area finding no more breeding, and nine worn *C. cantator*, five fresh *C. sollicitans* from the third Elizabeth brood and one worn *C. cantans*.

On the same day, out of fifteen examples caught in Mr. Renwick's garden, fourteen were *cantans* or *abfitchii* and one was *cantator*.

June 26th, Mr. Brehme and Mr. Grossbeck made another collection and examination of the pot holes. For over a week there had been frequent rains and enough time had elapsed since the first to bring out any mosquito larvæ that may have been ready to develop. But though many pools were found with water, absolutely no larvæ were present. Adults were still numerous and fierce and all save 3 to 4 per cent. of *cantator* were *abfitchii* or *cantans*. The latter were much worn, however, and survivors of the early May brood. "It was interesting to see how this species keeps to the woods. Ten feet from the woods not a specimen was to be seen, but upon entering a few feet into it one would be at once surrounded by a humming swarm. They alight without hesitation and bite directly. About 100 specimens were taken in less than ten minutes."

What Mr. Grossbeck says above shows that it is quite possible for two persons to collect over the same area and make quite a different showing at the end of the day. The one keeping in the open would get *C. cantator* almost exclusively, the one keeping to the woods would have a strong predominance of *C. cantans*.

June 30th, another trip by Mr. Brehme showed neither larvæ nor adults at Springfield. At Millburn no larvæ were found, but there were plenty of *C. cantator* and a very few *C. cantans*. In the woods the number of mosquitoes was materially reduced and larvæ were yet absent. On the South mountain there was no breeding, and of twenty-seven adults, twenty-one were *C. cantator*, very much

ırn; four were *C. sollicitans*, very fresh, and two were *C. can-* *ns*, very old.

July 7th, the South Mountain Reservation was dry, no breeding ıs going on, the woods mosquitoes were not in evidence, and as was quite windy, few of any sort were flying. Nine old speci- ens of *cantator* were taken, and there was no evidence that speci- ens from brood 4 of the salt marsh had yet reached this place. t Springfield everything was dry, and neither wrigglers nor lults were found.

July 14th, conditions at Springfield had not changed; at Mill- ırn no larvæ were found, but a number of fresh *C. cantator* were ken, evidently recent arrivals from the marsh. At Short Hills ıe woodland pools were free from larvæ and mosquitoes were uch less in evidence. At South mountain no larvæ were found, ıt there were fourteen fresh and four old *cantator* and three fresh *llicitans*. The old migration from the salt marsh was almost ne, and fresh specimens had arrived to take its place.

July 18th, eight fresh examples of the house mosquito, *C. ipiens*, were sent in by Mr. Renwick, the first of the season from ıat source, and on the 21st Messrs. Brehme and Grossbeck made ıother joint investigation. There had been frequent rains for me days, and it was believed that conditions for local breeding ıould be at their best. The Springfield avenue low area at Mill- ırn showed pools in the stream beds, some with and some without getation. In the more open pools *C. pipiens*, *C. sylvestris* and a w *jamaicensis* were breeding, while in those with vegetation *C. rritans* and *Anopheles* were found. There were plenty of adult . *sylvestris* near these pools, but none were found elsewhere on ıe meadow; they apparently remained very close to home. The rea between Millburn avenue, Morris turnpike and Short Hills ad was very wet, as usual, but absolutely no breeding was ob- rved in any part of it. Not a wriggler of any kind was found, nd only a few adults were found flying—all *sylvestris*. The pot oles in the woods were pretty generally filled with water, but bsolutely no wrigglers were found in any of them. Adults were ıoderately abundant, four of them badly rubbed *cantans*, one *C. iseriatus* and the others all *C. sylvestris*. The latter gave very ttle trouble, and was usually content to alight on the clothing, ıaking no attempt to bite. As the last sending from Mr. Renwick as all *C. pipiens*, and his sendings had been pretty generally

fresh-water forms, his house was located and found to be close to the woods and with trees, not a part of the original woodland extending well toward the porches. It was a situation which would readily tempt the sylvan species, and accounts for the predominance of *C. abfitchii* early in the season. No dangerous puddles were seen, though the grounds themselves were not examined, and attention was directed to the sewers. Several of the covering plates were lifted and beneath each was found a large settling bucket, full to the brim of dirty water. Most of them had no wrigglers, but some had, and directly in front of Mr. Renwick's house was a bucket with an egg-boat and numerous larvæ and pupæ. The local supply and recent occurrence of *C. pipiens* was thus readily explained, and attention was called to the matter.

During the day, while driving, the horse was frequently covered by mosquitoes, almost all *cantator*, and specimens of the same species were taken on Mr. Renwick's porch and in his garden. In the evening, on a hotel porch, both *C. cantator* and *C. pipiens* were taken—six of the former to one of the latter, but as there was considerable wind, mosquitoes were less than usually troublesome.

August 6th, breeding conditions from South mountain to Millburn were unchanged, and only a single lot of wrigglers was found. These were composed of six *C. serratus*, one *C. sylvestris* and one *Anopheles punctipennis*.

August 16th, Mr. Renwick sent in his last lot of adults for the season, composed of *C. cantator*, four; *C. sylvestris*, four, and *C. cantans*, two. This is the last appearance of *C. cantans* (more probably *abfitchii*) in the collections, and indicates a possible length of adult life of ten weeks—much longer than we had believed from previous experience, and that makes this single brooded species a much more serious pest than some other even more plentiful but shorter-lived species.

August 18th, Mr. Brehme, in tracing out the course of brood 6 from the Elizabeth marshes, covered the area from Springfield to Summit, and found ninety *sollicitans*, two *sylvestris* and one *pipiens*. On the South mountain the collections made were twenty-one *sylvestris*, five *cantator*, five *sollicitans*, one *canadensis*, one *triseriatus*. This was purely a tracer for adults and the search was continued on the 20th. From Millburn to South Orange road, seven *sollicitans*, three *cantator*, four *sylvestris*, one *triseriatus*. South Orange road to St. Cloud, two *sollicitans*, two *cantator*, four

ylvestris. St. Cloud to Montclair, seven *sylvestris*, one *cantator*. 'he dominance of the salt marsh fauna is well shown in this ollection, but the migration was not then completed, as was found ugust 27th, when one hundred and fifty *sollicitans* and twenty *antator* were taken at Millburn, as against two *sylvestris* and ine *pipiens*. On the South mountain, on the same day, were 'ourteen *sollicitans*, nine *cantator*, six *sylvestris* and one *Janthinosoma musica*. At Springfield, there were some pools and in them arvæ of *sylvestris*, *pipiens* and *Anopheles* were found.

September 4th, Springfield was still breeding the species above named and many larvæ were taken. *Sollicitans* and *cantator* were yet the dominant species, but the examples were beginning to look much worn, while *sylvestris*, which was the only other species taken, was very fresh and clean.

September 20th, practically all the breeding places in the entire area were dry, the salt marsh species had disappeared and only five *sylvestris* and one *pipiens* were taken during the day. The trip was made to verify the conclusion that marsh brood 7 was a stay-at-home, and that no migration had taken place.

September 24th and 25th, Messrs. Grossbeck and Brehme tramped the entire area under observation, and in the two days found only a single adult *C. sylvestris* and no larvæ at all. In the Springfield area of Millburn the stream bed, which had been broken up into pools earlier in the season, was now full, and no more breeding was going on. Nothing was found in any of the pot holes, and the swamp areas were all safe.

October 9th, matters were found in an equally good condition, so far as breeding is concerned, and in the day's search only five adults were met with, all *C. pipiens*.

October 16th, I went over the area myself with Messrs. Brehme and Grossbeck to verify the conclusions that they had reached, and to be able to speak of the character of the area from personal knowledge. The "pot holes" I found like those I had known in other places and none of them contained larvæ. From two of them that were dried out, or nearly so, a pail of surface soil was gathered, a shaving one-quarter inch, or a little more, being taken so as to include the decayed leaves and the mud surface just beneath them. This was carefully examined later, in the laboratory, and mosquito eggs were found imbedded in it. These eggs were like those of *sollicitans*, but distinctly larger, and therefore were

not those of *canadensis* which I have had, and which are smalle They were probably either *cantans* or *abfitchii*. None of these eg hatched under laboratory conditions.

These pot holes are real danger points, and more particular the smaller, less permanent ones, and they need attention, thoug they produce only a single brood annually.

As to the rest of the woodland and swamp areas, they need litt or no attention, and no signs of breeding were observed. Alo some of the roadsides water-filled depressions were seen, and some of them larvæ of *C. sylvestris, C. restuans* and *Anophel punctipennis* were found in small numbers.

This series of observations carried on throughout the seas demonstrates that for the entire area covered by it the salt mar species are the dominant and annoying types, except in the woo in which the pot holes occur, and there *cantans, abfitchii* or *can densis* may be expected to be the pestiferous forms. The occu rence of *abfitchii* this year is quite out of the course of our e perience and may not be repeated for some years; but, on t other hand, the experience may be duplicated next year. O stock of facts is as yet too small to make it safe for us to generali or predict.

All of the inhabitants of this region are affected by the mar mosquitoes; only those who live very close to or actually in t wooded area are apt to be troubled by the sylvan species. The are no dangerous swamp areas of any extent anywhere within t surveyed area. There are several places where pools form at tim and from which *Culex sylvestris, pipiens, restuans* and *Anophel* are bred in greater or less numbers, but most of these places ca be easily and cheaply abolished. It is quite probable that the are places where *Culex pipiens* breeds that can only be found by house-to-house inspection and which we could not find because v entered no enclosures.

The drainage of the Elizabeth and Linden marshes, which is be undertaken in 1907, will give relief from the salt meado species and will leave the sylvan forms as the principal source trouble from May to mid July. Just how far the individuals f within the woodland we do not know; we do know that they wi not go outside of the woodland or from the shelter of trees. It not probable that any stretch of open would be crossed to get fro

one patch of woods to another, but even a wide road through the woods would be freely crossed at night, though no mosquitoes would be found on it during the day.

A few of these pot holes may be easily and cheaply drained, and that will be the best way of getting rid of such. A great many of them can be easily filled with soil from the surrounding hillocks. There will remain a considerable number that cannot be easily drained and which it would be rather expensive to fill in the ordinary way. These would have to be dealt with by oiling or by making them unsuitable for mosquito breeding. Oiling is usually an unsatisfactory makeshift and not to be recommended, and yet it deserves consideration in this connection because it would have to be done once only. None of the sylvan species except *C. canadensis* have more than one brood, and this matures in late April or early May—usually the latter. A couple of men with knapsack sprayers and a supply wagon could cover a very large area in one day and could oil-cover the pools in it so thoroughly that few larvæ could come to maturity. Done once, the task would be finished for the season, and each year would make it easier, since persistent thorough work results in practical extermination in all the easily accessible pools. The matter is worth careful consideration.

To render the pools unfit for breeding places would mean to cover them in such a way as to prevent the larva from getting free access to the air. These pot holes are natural sinks into which the water drains from the surrounding slopes, but while the hole may be inevitable, it need not remain freely open to mosquitoes. It could be loosely filled with stones and boulders, over which logs and branches could be piled in such a way as to form a rather solid covering to the pool so dense as to make it uninviting as a breeding place. Mosquitoes do not like too much shade, and even a filling with branches of trees cut into short lengths would be sufficient in many instances. This would cost more than oiling, but would be more permanent, though it would have to be looked over at intervals of two or three years.

As to the other breeding places for *sylvestris* and its companions, a few intelligently-placed ditches, a little filling and a few culverts or pipes across roads will be nearly all that is necessary.

New Durham.

Early in May, after some correspondence, I met with a committee from the board of trade of New Durham to look over the general mosquito situation. The town is on the Palisades, and the slope is abrupt to the Hackensack valley. The Erie and New York and New Jersey railroad tracks run between the foot of the Palisades and the Penhorn creek, leaving a considerable swamp area to which the railroad embankments serve as an outer dam. There is also a swampy area between the two lines where, at the time of my visit, water was standing, but no wrigglers were apparent.

Mr. Brehme was detailed to make a more careful study of the surroundings, and did so on May 15th. The cat-tail and reed-covered area of the valley had been under observation for two years previously, and was known to be safe, yet it was again examined to make certain that conditions remained the same. It was found also that while at the time of the examination no larvæ were present, a part at least of the swamp area basing the Palisades might become breeding ground for *C. pipiens* or *sylvestris*. This danger area was mapped out, a ditch system for its relief was suggested, and on the evening of the 23d a public lecture was delivered at the town hall under the auspices of the board of trade.

The matter was then left with the local authorities as one that did not come within the scope of the State Aid law, but it was also agreed that the territory would be kept under observation during the season.

June 28th, Mr. Brehme made a second investigation and found that the breeding places had been over, rather than under, estimated, and that some of the supposed dangerous ground was then so densely overgrown that no larvæ could possibly breed in it. And this safe condition persisted during the balance of the year. At this time some mosquitoes were noted early in the evening, and nine *cantator*, seven *sollicitans* and one *pipiens* were taken—sixteen salt marsh specimens and one local.

July 19th, conditions in the suspected areas were still good, but mosquitoes were very abundant. The wind had been from the southwest for several days and representatives of brood 5, from the Jersey City meadows, were on hand. Yet *C. pipiens* was well

epresented, also, and the question was where did they come from. [here are no large breeding areas, so there must be local condiions on enclosed property, which are only within the jurisdiction f the health officer.

August 22d, on another visit, breeding places within the town imits were sought out and quite a number were found—some in ools in depressed lots, but more in gutters, where larvæ and pupæ vere plentiful. The excess of rain, which kept such places contantly full, was responsible for much of the mosquito trouble. [he vast majority of the adults were of the salt marsh species, owever, and representatives of brood 6, which was just out from he Jersey City meadow.

A report of all our findings was duly transmitted to the board f trade, at their request, and will form the basis of whatever ositive action is taken in the case.

Lake Hopatcong.

This pretty lake is becoming increasingly popular each year, nd not only are hotels and other resorts becoming more numerous, ut camps have been and are being established in the woods round bout. Complaints of mosquito troubles are occasionally received, ut the general belief seems to be that the lake itself is responsible, nd that therefore nothing can be done—that it is simply one of he drawbacks inseparable from any body of water. Nothing is urther from the truth, and it had been intended to keep a rather lose watch on the locality during the summer. This proved to be mpossible, owing to press of other work.

Two days' collecting was done—May 5th and 6th—by Mr. Grossbeck, on the east side of the lake, through the swampy area nd among such woodland pools as were found. Larvæ of *Anoheles* and *C. sylvestris* only were found on this trip, which was oo late for the spring forms, and these larvæ were in a single ool close to an open field. Neither of these species are true woods nosquitoes, and frequent either open areas or get as near to them s they can. As to the adults, *C. aurifer* was very abundant and n good condition in one section of the woods. During a rest of wenty minutes twenty examples were taken and pinned, out of he hundred or more that were hovering about—and not only

hovering, either, for Mr. Grossbeck found them as vicious as Mr. Brakeley did at Lahaway in former years. Where this *aurifer* occurred it was the only species and probably bred close by, although no breeding place could then be identified as such. The records made by Mr. Brakeley prove that this is one of the single-brooded species, maturing in April, but that the adults may live until midsummer, ready to bite viciously to the end. Mr. Brakeley's observations further prove that the species does not occur each year in notable numbers, but that in some seasons neither larvæ nor adults can be found in places where the year before both were abundant, even where the conditions of moisture are approximately identical.

"In another section, an open swampy area, *C. trivittatus* flocked about me while walking, and they bit readily. Numbers were disturbed in and rose from the grass, alighting on the lower part of my clothing. This is the smallest mosquito that I have ever found in numbers in the field eager to bite, so it attracted attention at once. All the specimens were badly rubbed." This is the earliest record that we have for this species, and indications now point to successive broods throughout the summer. That it bites readily is now also established, but thus far no examples have been found in or about dwellings.

In yet other parts of the woods *C. cantans* were found commonly, and they bit ravenously. The specimens were very much worn, as if they had been on the wing for some time, and it is possible that there may have been an admixture of one of the other species that are closely allied in the adult stage. On the porch of the hotel a few *aurifer*, one *canadensis* and two *perturbans* were taken at dusk, showing that these may become nuisances.

July 7th, another visit was made, this time to the southern end, and with the especial object of determining whether one of the smaller lakes or ponds, on the edge of which a club-house was contemplated, was a mosquito breeder. It was found that it was not; that the pond had clean edges; was without shallows or vegetation rising above the surface, and was well stocked with fish. In the woods around about *C. cantans* was still found in considerable numbers, and there were also found the pot holes, some yet containing water, from which these specimens had been bred earlier in the year. No larvæ of any kind were found in the pot holes

that contained water, but in a shallow pool in an open field, larvæ of *Anopheles* and of *C. territans* were found.

The problem at Hopatcong is a purely local one, and neither the main lake nor the smaller lakes or ponds near it are to be accounted as sources of danger. The pot holes and other woodland pools which produce a brood of vicious biters in early spring need attention, and must be dealt with as local conditions indicate.

Mount Holly.

Mount Holly is a flourishing community with a population ranking high in prosperity and intelligence. It is the county seat of Burlington county, one of the most important in the State, and it is the centre for the surrounding agricultural section, which comprises some of our best farms and orchards. That Mount Holly should have an improvement association is not surprising, and that this association should consider the subject of getting rid of the mosquito pest is only natural. At the request of this association, Mr. Grossbeck visited Mount Holly June 8th, and what he found is best shown in the report, which is here given verbatim as made:

"*Mount Holly Improvement Association:*

"GENTLEMEN—*Pursuant to your request that a mosquito* investigation be made in Mount Holly and its breeding places located, I beg to submit herewith my report:

"The town was inspected on June 8th of the present year, in company with your president, Mr. Joseph R. Gillam. Your town, as you are probably aware, is without the limits of the migratory salt marsh mosquitoes, so it follows that all the nuisance is caused by local species, the principal one of which was found to be *Culex pipiens,* the house or the rain-barrel mosquito. This species was found in countless numbers throughout the town. There were also found a number of places which are typical for a luxuriant development of *Anopheles* or malaria carriers. Indeed, this species was found breeding in certain barrels, but in such places they occur only in comparatively small numbers.

"Following are enumerated the different breeding places found and remedies are suggested for their elimination, which where feasible are of a permanent character:

"At the northwest corner of Washington and King streets the ruins of the carpet mill enclose a large pool of water which is uninhabited by natural enemies of mosquitoes of any kind. This body of water, though free from mosquito larvæ at the time of investigation, is, nevertheless, subject to their invasion, and will undoubtedly harbor millions of individuals before the end of the season. This place can be easily drained into the Rancocas creek by an open ditch and the area thus made safe. Between the mill and Washington street the land is low and wet and in times of continual rains will become dangerous. Therefore a ditch should be made to connect with the one to drain the pool just mentioned which will render this place dry at all times.

"There are five wooden railroad bridges crossing the Rancocas creek and at each of these are several barrels sunk into the earth and filled with water. Most of these were swarming with mosquitoes in all stages from egg boats to pupæ, and freshly-emerged adults were to be seen resting on the surface of the water. In one of these barrels were found, also, a number of larvæ of the malaria-carrying species (*Anopheles*). Tightly screening these barrels so as to prevent the entrance of adults would be the best remedy, but this recommendation may be difficult to carry out since it partially destroys the purpose of the barrels. Petrolizing, *i. e.,* pouring crude petroleum on the water, is the next best thing that can be done, but this will have to be repeated at intervals of a week or ten days. This is a very effective method for killing the larvæ since it shuts off their only means of obtaining air, but on account of the liability of its being neglected or procrastinated it is not recommended except when no permanent method is possible.

"There is a small area south of the railroad station south of Washington street which, though quite safe, will breed *Anopheles* and *Culex territans* in small numbers. This place should be drained by a few ditches into the creek.

"In the meadow at the foot of Bispham street, between the railroad and the creek, and known as Parson's meadows, are several small ditches which widen out at places forming shallows with a luxuriant growth of water vegetation. These are ideal breeding places for *Anopheles* mosquitoes. All these ditches should be deepened and the edges kept clear from vegetable growth, thus giving the water a free circulation and incidentally giving ready access to the small fish which are numerous in the nearby creek.

"The partially wooded area south of the railroad called Spout's Spring woods is not a breeder of species which are classed as nuisances, but in many of the open spots *Anopheles* will develop, and it therefore needs some attention. It can be drained by open ditches into the creek. Should work in elimination of breeding areas be commenced by the improvement association, I would suggest that this be the last of the places to be dealt with.

"The area north of the railroad and west of St. Andrew's cemetery has precisely the same conditions as Parson's meadows, and the recommendations given for that territory applies to this as well.

"Directly to the rear of the Relief Fire Engine House was found a very large pool. This contained millions of *Culix pipiens* larvæ and pupæ, and in itself could supply the town of Mount Holly with a plague of adults. Considering the number of broods the pool would develop in one season, the number of individuals in all would run into an unpronounceable row of figures. A series of somewhat smaller pools followed this, and all are dangerous, though all did not contain larvæ when examined.

"The old raceway from the dam to the old grist mill was found to be a prolific source of mosquito breeding, both for *Culex pipiens* and *Anopheles*. Large pools have formed in the deeper depressions and I understand that these are only rarely connected by a continuous channel of water. The same conditions were found below the grist mill, where a single dip of an ordinary glass brought up a wriggling mass of mosquito larvæ. This place, I am informed, is to be permanently remedied by the building of a dam across the Rancocas creek, thus directing a steady stream of water through the raceway. Until this permanent work can be done, petrolizing the pools at intervals of ten days is recommended as a temporary expedient.

"Near the Grant street station there is a small, wet area, which was found to be breeding *pipiens*. This can be drained very easily into the sewer pipe.

"To the rear of dwellings on Water street, just west of King street, were found many puddles formed by the sewage from the houses. These were simply blackened by thousands of pupæ which crowded the surface. There are undoubtedly other such places in the town, as well as open ditches at the sides of the roadway in which surface sewage gathers, and all such give rise to perfect

clouds of mosquitoes many times in the course of one season. I am informed that there is a good sewerage system in Mount Holly, and if all dwellings were connected with this these surface sewage pools would be eradicated."

In order to bring the matter more prominently before the public, Mr. Dickerson delivered a lecture on the subject, June 11th, detailing the life history of the offending species and explaining just how the measures proposed were expected to produce the desired result.

The Improvement Association also republished the figures of the "Mosquito and the Puddle," first sent out by the Village Improvement Society of South Orange, and continued its campaign of education throughout the season. Unfortunately it proved impossible to secure the active co-operation of the authorities, and the character of the season was such that, with the supply found by Mr. Grossbeck to start on, every rain pool developed house mosquitoes when the rains came.

Mount Holly is out of the range of the salt marsh species. Its problem is a purely local one; is of such a character as to require only the simplest sort of local work, and such as to enable it to secure almost complete exemption by permanent improvements of not too expensive a character. It would be a reflection upon the intelligence of the municipal government should such conditions be allowed to remain much longer, especially where the board of health has ample power to compel abatement.

Other Local Work.

At the requests of either individuals or of the health or municipal authorities, local inspections were also made at Rahway, South Amboy, Barnegat City, Irvington, Plainfield, Montclair and Paterson, and in most cases reports were made to the parties concerned or who requested the investigations. Other communities sent in specimens for determination and a few localities were collected over for our own information.

The outcome of most of these inspections was to determine that the frequent rains and sultry weather of the late summer had furnished breeding places for *C. pipiens* in altogether unusual numbers; that every depression that could hold water was filled, and that wrigglers were present in almost every instance.

CULICIDE.

This material received its trial in New Orleans during the yellow fever epidemic and proved positively successful in destroying all mosquitoes in the rooms and buildings in which it was em-

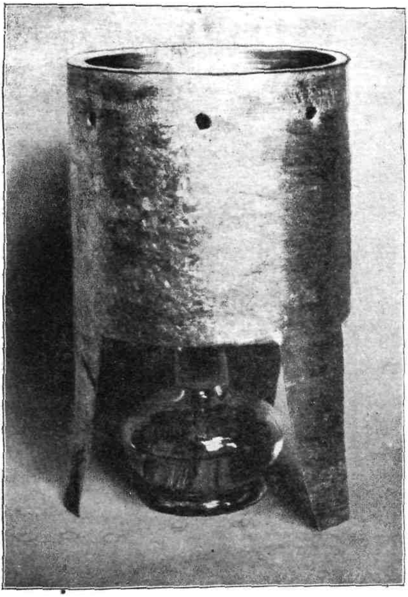


Fig. 7.

Fumigating outfit for Culicide. Made of a section of five-inch galvanized iron stove pipe, a tin dish and a glass alcohol lamp. From an original photo.

ployed. It is made of equal parts by weight of carbolic acid crystals and gum camphor. The directions are to melt the carbolic acid crystals over a gentle heat and pour over the gum camphor;

the acid will dissolve the camphor and leave a clear, somewhat volatile liquid with rather an agreeable odor. In actual practice I placed the bottle of crystals in a can of warm water and allowed it to liquify gradually, pouring the liquid over the camphor from time to time until no more acid remained. The resulting solution is permanent and may be kept in tight jars or bottles indefinitely.

The directions are to evaporate three ounces of this Culicide for every 1,000 cubic feet of space in the room or building to be treated and to keep such space tightly closed for a period of at least twenty minutes. Neither metals nor delicate fabrics are affected by the vapor, but besides mosquitoes it also kills flies and other insects. The liquid is inflammable, but not explosive, and as it requires heat to volatilize it, the apparatus should be placed in a pan or tub of water to avoid danger of fire.

Surgeon Berry, of the Marine Hospital Service, who gives an account of his experiments with the material in the Public Health Report for February 2d, 1906, Vol. XXI., No. 5, recommends as an outfit: "Galvanized iron stove pipe eight inches in length. Cut out sections from bottom so as to leave three legs, the cut-out sections giving entrance to air. This pipe is put over an alcohol lamp. In the upper part of the pipe make half a dozen air holes about one-fourth of an inch in diameter to provide a proper outlet for the draft. On top of the pipe place a pan in which the evaporation takes place. A granite ware wash basin answers every purpose and is better than anything else, because it evaporates the liquid completely."

In accordance with the above suggestion, I made the apparatus shown in Figure 7 out of five-inch stove pipe, and in a tin flat-bottomed basin that fitted into the top of the pipe evaporated two ounces of Culicide in twenty-five minutes, using one-half an ounce of alcohol in an ordinary glass alcohol lamp. A tin basin was used because it would heat up faster, and by measuring out at the rate of one ounce of alcohol for four ounces of Culicide complete evaporation may be obtained without danger of burning out the apparatus. It is possible to remain in the room until fumigation is well under way and the vapor becomes quite dense, and the room may be entered again when the work is completed after a door or window has been allowed to remain open a few minutes. Although

it has been found that twenty minutes' exposure is sufficient to kill mosquitoes, it will be better to allow rooms to remain closed tightly at least an hour after the material has completely evaporated. The quantity given, three ounces to 1,000 cubic feet of space, presupposes a moderately tight room to be fumigated. If doors or windows are leaky an excess should be used, and in large cellars, for instance, two or three fumigators are better than one to secure more rapid evaporation.

The entire outfit exclusive of the lamp, but including the charge of the tinman for cutting and punching the pipe, was forty cents. The actual outlay need not be over fifteen cents. Wood or denaturized alcohol will answer every purpose, so that the cost of the fumigating outfit is very small.

Killarvæ.

This is a preparation consisting of two powders which, when united in the presence of water, evolve or form ammonia. The water becomes more or less charged with this ammonia, in proportion to the amount of material used, and it is given off from the surface, as the very decided odor proves.

The preparation comes from the Nienstadt Laboratory, at Hoboken, New Jersey, and a sample was sent in for trial in May, supplemented later by a purchased lot, to be tried on a more extensive scale.

Quite a number of laboratory experiments and experiments on small areas were made, but condition proved adverse when a large area was undertaken at Barnegat, a brood having just come out of the pools and the water being clear at the time.

July 10th and 11th, applications were made to some lot pools containing larvæ of *C. pipiens* and *C. jamaicensis* at varying strengths, from that recommended on the packages to a concentrated mixture.. The result of these experiments was, on the whole, unsatisfactory, and on July 18th the experiments were repeated, with Dr. A. E. Nienstadt, the inventor of the compound, in attendance. Four lot pools with large numbers of wrigglers were treated, and into each a large amount of the mixed powders was stirred. The pools varied in size and the ammonia odor was obvious in all cases. Check experiments were also carried on in

the laboratory, and the result was the destruction of nearly all the larvæ in all save one of the pools. Egg boats were also placed on the surface of treated water in the laboratory experiments, and these failed to hatch, while others from the same lot and placed on untreated water developed larvæ normally.

The net result of these experiments was that if used in sufficient quantity the "Killarvæ" does really kill mosquitoes in all stages, and the strong odor of ammonia rising from the surface will probably prevent oviposition for a short time.

Two days later, July 20th, Mr. Grossbeck re-examined the lot pools, found them partly dried up, but what water remained no longer had an alkaline reaction, and there was a new crop of young wrigglers. In other words, the pools were not protected for more than twenty-four hours.

This is not really surprising, for, since the killing power of the material depends largely upon the ammonia developed, it would cease to be effective as soon as all the ammonia was dissipated, and that goes very rapidly.

As compared with petroleum, "Killarvæ" is no more effective, and is, in fact, less certain, where pools are irregular and encumbered with vegetation. Nor does it protect for so long a time, for in a quiet pool the oil will serve for a week or two, while the "Killarvæ" disappears altogether in a day or two. Its only advantage over the oil is its cleanliness, and it may have a distinct and useful field in dealing with those woodland pools in which only a single spring brood develops. In this case any material that will with certainty kill off the larvæ before they have a chance to come to maturity will serve to free the treated forest district for an entire season from the offensive species that infest it. In such places as the Essex county parks its employment would be well repaid.

Report Upon an Experiment Having for its Object the Introduction of Gambusia Affinis and Heterandria Formosa to the Waters of New Jersey as Destroyers of Anopheles Larvæ.

BY WILLIAM P. SEAL.

It is probably best to premise that, as far as ocular evidence goes, the experiment in question has so far proven a failure, but it is not absolutely certain that this is the case, nor would it be proof of its impracticability. Having originally suggested the experiment, the writer, at the solicitation of Prof. John B. Smith, consented to carry it out.

In a paper presented at the last meeting of the American Mosquito Extermination Society, entitled "Fishes in Their Relation to the Mosquito Problem," the writer took the ground that the distribution of fishes for the purpose of mosquito extermination is as properly the function of fish commissions as the same work in the interests of sport, or even of food-supply, inasmuch as it relates to both the health and comfort of all our citizens, including the sportsmen.

It may be well, also, to note here that the writer suggested the same experiment to the United States Fish Commission as early as 1901, and was informed that "it was a subject not relevant to the functions of the commission, but pertinent to the Division of Entomology, Department of Agriculture." It is interesting to observe that the United States Bureau of Fisheries is now making the same experiment by the introduction of *Gambusia* and allied species from the costal waters of Texas to the canals and irrigating ditches of Hawaii.

The writer, in all suggestions on the subject, insisted on the month of March as the most favorable time for making the experi-

ment, for the reason that even if the fishes were inclined to escape from the waters in which they were placed, as an uncongenial environment, some of them would surely remain long enough to breed, and the young would most probably not be inclined to leave the place of their birth. It is a fact well known from experience with the food varieties that the larger species of fishes cannot be successfully introduced into waters which do not fully meet their requirements, and the rule holds good with all larger animal life. How far the rule will hold good with species so small and insignificant as *Gambusia* and *Heterandria* can only be determined by experiment. When once a species breeds in a locality its spread is generally only a question of time. It is, therefore, apparent that persistent and continued effort is necessary in making such experiments, and the greater the scale on which they are attempted the greater and more speedy will be the results.

As certain exigencies prevented the making of the experiment in the spring, it was deemed worth while to make it in the fall, so as to avoid further loss of time, and in the belief that there was a good chance for at least a small measure of success. The summer of 1905 was phenomenally dry, the drouth extending through the fall and greater part of the winter, so that many places naturally adapted to fishes like *Gambusia* and *Heterandria* were almost dry. If the fish had been living and breeding in these places all summer it would have made little difference, but in the cold season they were unfit as places for stocking.

The weather remained so warm throughout the fall that it was deemed undesirable to attempt to ship the fish before November, as the temperature in North Carolina, from which State they were brought, in that month was much like the month of June in New Jersey. In November, therefore, something over ten thousand were successfully shipped to Delair, New Jersey, from which point they were distributed as follows:

About 8,000 in spring and natural drainage rivulets flowing into the ice pond at Westville;

Six hundred in a land-locked pond near Delanco;

Six hundred in a mill pond between Merchantville and Evesboro;

Six hundred in land-locked waters near Delair;

Four hundred in ponds of the Aquarium Supply Company, at Delair.

The selection of the places for making the experiment was governed in the main by the desirability of convenience in maintaining some sort of espionage over them during the winter.

One of the small streams leading to the Westville pond comes from springs at North Woodbury. Another comes from the direction of the Delaware river, and it is now believed that in time of heavy rains small fishes could make their way to similar small rivulets flowing to the Delaware, but dense growths of briars prevent a complete examination. It must be, therefore, a matter of conjecture whether these fishes were devoured by the black bass, pike, yellow perch and sunfish inhabiting the Westville pond, or whether because of their enemies or dislike to their changed conditions they found their way during the spring rains to rivulets flowing to the Delaware. Some of them were seen during the winter and as late as March half a mile or more above the pond, and some still further up.

The Westville pond was looked upon as the most favorable in this section for the experiment, as affording average conditions, the possibility of escape by pushing up the rivulets leading to it not then being suspected; this, however, as before stated, being at present a matter of conjecture only.

When the fish were deposited the temperature of the water in the rivulets at Westville was about 45° F., or spring water temperature, and they seemed comfortable in it, but soon took refuge from the current in the grasses fringing the banks, disappearing completely from sight. In the other places the water was colder and the conditions more unfavorable and none of the fish were seen afterwards, and they probably succumbed to the cold or were devoured. In the ponds of the Aquarium Supply Company hundreds of young pike about one-half to three-quarters inch long were found in March, the breeders having found their way in through muskrat holes in the banks. In about sixty days they were four to five inches long, but not so numerous, their development representing the destruction of their kindred and all other species. It is the presence of the predaceous species everywhere that makes such experiments so difficult. In recommending that the supplying of fishes for the purpose of mosquito extermination be placed in the hands of the State Fish Commission, if it be deemed desirable to continue the experiment, the writer is actuated by the belief

that they will gladly undertake it if so authorized, and that wit their extensive equipment and facilities the experiment can b made on a scale of such magnitude that success will be assured.

March, or not later than April, will be found to be the best sea son for shipping them by express. If accompanied by a fish com mission messenger, May would not be too late. At all events th spring months are the proper ones for this work. The earlier th better. Then with the entire spring and summer for breeding, th multiplication will be manifold.

Gambusia affinis and *Heterandria formosa* are the smalles Cyprinodonts found on the Atlantic coast. They are viviparous surface-feeding, larvæ-eating, minnows, know as "top-minnows." A study of the breeding habits of a pair of *Heterandria* during th past summer showed the extrusion of young at intervals averagin a week from June 13th to September 10th, some fourteen deliv eries in all. These varied in the number of young extruded, bu a fair average would be ten, although as high as eighteen were found on one occasion. Some were undoubtedly eaten when other food was scarce, though in the cases observed it might have been a parallel to what has been observed of other species where the young appeared to be devoured because they were deficient in vitality. Taking it, however, at the average of ten, there would be an increase from the one pair of one hundred and forty. Nor is this all. A pair born in June brought forth young in August and another pair did the same in September, thus producing a second generation within four months. It will thus be seen that they are wondrously prolific. Although they do not have the enormous fecundity of most fishes, the young are protected during the egg stage and are born able to take up the burdens of existence with a much greater chance of escape from their enemies as they are fully developed and very active at birth.

It can be safely assumed that the breeding habits of *Gambusia* are identical with those of *Heterandria.*

It is an established fact that these two species are largely feeders upon the larvæ of mosquitoes, and that because of their small size and habit of swimming and feeding at the surface, they can penetrate among and over aquatic plants as no other species can or do, and for this reason are especially adapted for the destruction of the larvæ of *Anopheles.* This phase of the question has, however, been quite fully explained and should be fully understood.

This report needs little comment; it is clear and to the point, nd while the experiment is written down a failure it has taught us hat must be avoided if success is to be secured, and it has taught s something concerning the limitations of the species. Concerning the desirability of securing the introduction of these little minows into the State there seems little room for doubt, but the task s really beyond the scope of the mosquito work and should be laced where it belongs, *i. e.*, with the fish commission. There is o reason to believe that this commission will not be willing and ully competent to do all that can be done if the matter is referred o it with sufficient funds to cover the expenses involved.

MOSQUITOES OF THE SEASON.

Notes by John A. Grossbeck.

The summer of 1906 was rather a rainy one until the latter art of August, consequently favorable for prolific production of osquitoes, and complaints were received from many points in the State. Upon investigation, the species in most cases proved to be *ulex pipiens,* the common house mosquito. This species is in ome respects more of a nuisance than the salt marsh form, this atter being content to remain outdoors or to enter houses on the lothing, while the former's habit is to force its way into dwellngs—through the meshes of the screen, if there is no more conenient method. As a rule, such complaints came from localities ithout the range of flight of the salt marsh species, but this does ot mean that salt marsh mosquitoes have been less in numbers han usual, except in the drained areas, or that inland towns ared worse than shore municipalities, but the shore communities re never without mosquitoes in summer and the presence of addiional specimens was not so marked.

The house mosquito also occurs along shore, sometimes in considrable numbers. The weather conditions of the season, as elsehere, favored their development more than in ordinary years, ut *C. sollicitans* and *C. cantator* are always the predominating pecies, and so *C. pipiens* is much less noticed than would be the ase if salt marsh forms were absent, or nearly so. For instance, t Monmouth Beach, prior to 1904, one could collect hundreds of pecimens, and most of them would be found to be *C. sollicitans*

or *cantator*. After the marsh surrounding this town was drained, the inhabitants enjoyed two years of solid comfort in having almost no mosquitoes. In the early part of the past summer, however, they were considerably annoyed and the work done on the marsh was questioned by some in consequence. Mr. Brehme, upon investigating the region, reported that he found *C. pipiens* breeding in great numbers in many places in the town—in neglected gutters, depressions in city lots, etc.—and, incidentally, going over the drained marsh area, he could not find any breeding going on there.

Two other closely related inland mosquitoes which were common and troublesome in 1906 are *Culex abfitchii* (*siphonalis*) and *Culex subcantans* (the *cantans* of previous reports). Prior to this year the former was regarded as rare and the latter had not been common since 1902. These two species are difficult to separate in the adult condition—in fact, in slightly flown specimens it is impossible to do so with any degree of certainty, the usually more robust appearance of *subcantans* being then the only means of discrimination. In the larval stages, however, the differences are marked and readily noticeable to the unaided eye, the most striking feature being the long and much more slender air-tube in *abfitchii*. Both these species are strictly sylvan in character, breeding only in woodland pools with *Culex canadensis*, and do not travel far from the immediate shelter of the trees. There is but one brood a year, the young larvæ hatching in early spring from over-wintering eggs and the adults issuing toward the last days of April, and continuing to emerge until the middle of May. Unlike most woodland species, these adults remain on the wing for several weeks, disappearing only in the last days of July. They are exceedingly hard "biters" and do not hesitate in making their presence known to anyone who enters their domain, but they voluntarily leave as soon as the open fields are reached. Dwellings situated near or among the trees where they occur are very apt to be troubled by these two species on the porches and in the gardens. They occurred in large numbers in the wooded districts of Millburn and Short Hills, Essex county, where they were taken in the first days of May as full-grown larvæ and later as adults. They occurred, also, in smaller numbers in the South Mountain Reservation and in the Great Piece meadows, and adults were taken plentifully in Paterson, on the Garret and Preakness

ountains, and in the woodland surrounding Lake Hopatcong. ur experience with these two forms has been such as would lead to believe that next season they will in all probability occur in r less numbers, if they will *not* be *altogether absent.* Just iat causes these broods to increase or diminish in numbers, as e case may be, is unknown; but it certainly does not depend ion the amount of individuals present the preceding summer, id if it be the conditions of the weather it must be from the ne the eggs are laid until the beginning of the following winter, ice from the time winter begins until larvæ appear in the pools asons are much alike as regards the condition of places where gs are laid.

The coast mosquitoes do not depend so much upon weather contions as the inland species, since the pools in which they live e created by the tides as well as by rains. Nevertheless, in a mmer such as 1906, the number and size of the broods is greatly creased. Thus the season was an ideal one for sending forth continuous stream of adults until the droughty condition of the te summer put a check upon the rapid succession of broods. In e northern section of the coast line, and probably also in the uthern half, *Culex cantator* was the dominant form in early ring. Toward midsummer *C. sollicitans* began to appear in a ther large percentage, though somewhat unevenly distributed to numbers. At Elizabeth and Linden they were about evenly vided; at South Amboy and Staten Island almost the whole of e broods were composed of *sollicitans*, while in Jersey City *cantor* held the largest numbers. Toward the end of the summer, the section from Barnegat bay southward, the broods were enrely made up of *sollicitans*, while north of this point *cantator* was esent in only a small percentage.

Other less common mosquitoes.—Of the species of *Anopheles*, *unctipennis* remains by far the most common, appearing almost ways in collections of *Culex pipiens*, whether from gutters, lot ools or rain barrels. Female adults were found flying as early as pril 21st at Paterson, and larvæ began to appear all over the tate in late May. They were most abundant in August, after hich, the pools drying out soon after, they could only be found springs, barrels and pails in which they were taken as late as ctober 18th.

Anopheles maculipennis has been rare for the past two or three years; in 1905 it was not taken at all in the larval condition, and in 1906 only a single adult was bred (June 1st) from a collected pupa from a "kettle-hole" at Millburn.

Anopheles barberi, discovered in New Jersey last year for the first time, was turned up by Mr. Brakeley at Bordentown, where he took adults in a bedroom at night: August 14th, one male; August 15th, one male and one female, and August 16th, two females. Another male was bred September 11th, from a lot of pupæ taken from a tree-hollow at Chester.

Anopheles crucians were taken in miscellaneous salt marsh collections at Barnegat City as small and medium-sized larvæ August 16th and September 6th, and at South Amboy as large larvæ and pupæ September 10th.

Psorophora ciliata was apparently rare throughout the season. Few larvæ were collected and adults were taken at Belleville, Paterson and in the Great Piece meadows.

Janthinosoma musica adults occurred plentifully in the Great Piece meadows August 27th. About twenty-five females were caged and fed on ripe banana and on human blood in hopes of getting eggs, but all died within ten days without ovipositing. Several adults were also taken at Lakehurst, August 16th.

Culex jamaicensis larvæ were found at Newark on July 25th; in pools along the speedway at Millburn, July 26th, in small numbers associated with *Culex pipiens* and *Anopheles;* and at New Brunswick in lot pools in great numbers on July 20th. This is undoubtedly the most rapidly developing mosquito in New Jersey. This was demonstrated at New Brunswick where larvæ as large as those of *C. pipiens* at maturity appeared July 20th, in pools which were absolutely free of mosquito life two days previous. On the 21st the larvæ were full grown, and among them were several recently-formed pupæ. It is worthy of note, perhaps, that, of this series of pools, only one contained *C. jamaicensis* and in that no *C. pipiens* were present, while in the adjacent pools *pipiens* were crowded in myriads and not a *jamaicensis* larva could be seen. Of the specimens collected for rearing a single male emerged on July 22d, making at most a four-day period from the hatching of the egg to the issuance of the adult. On the 23d, ninety males and twenty-five females emerged and all the larvæ had pupated, showing that the

eggs hatch and the larvæ develop very evenly. Many adults of both sexes were confined in breeding cages, one lot being fed only on ripe banana, the other exclusively on human blood. The latter took blood readily and gorged themselves so as to be utterly unable to take wing from a flat horizontal surface, though from a vertical surface they could fly short distances either higher or lower than the starting point, the tendency being to go downward. On a flat surface they could only hop about in a very comical manner. Of the examples fed on banana none lived above seven days, and of the blood feeders only two were alive August 6th, where one laid eighteen eggs upon the dampened lint, which was supposed to take the place of mud. They were laid singly, simliar to the manner in which *Culex sollicitans* lays her eggs; they were also of the same shape as those of that species but slightly larger. They were evidently not fecundated and failed to hatch whether covered immediately with water or left to dry out for several days before being water covered.

Culex discolor, though sent in from Delair by Mr. Seal every year since he first discovered it, is not as yet known to occur in any other part of New Jersey. A lot of full-grown larvæ were collected August 10th; on the 11th seven examples pupated which produced adults—all males—on the 13th. The remaining larvæ failed to pupate and grew more and more sluggish until their death—the last living until the 31st.

Culex perturbans as a larva remains unknown in nature though the young larvæ have been hatched during the past summer from eggs laid by a captive female. Though we have not succeeded in bringing the larvæ to maturity and thus establishing the character of their food, we nevertheless believe that we have taken a long step toward the final discovery of these early stages in a state of nature. The first record for *perturbans* in 1906 came from Mr. Brakeley, who found females sparingly at Lahaway in the last week of May. On June 8th he caught a male, the second example of that sex taken by him. From that date on the species became more common, but no more males were among the captures. Lakehurst, with its numerous creeks which flow through and spread over large and low-lying cedar and other woodland areas, represents conditions in which no known mosquito larvæ breed, and was carefully investigated for the larva that never occurred with other col-

lections of mosquitos. The locality was carefully examined in May before the first adults appeared and several times later in the summer, but nothing in the way of a mosquito larva was taken. On August 27th female adults in a very fresh condition were taken in the Great Piece meadows. They were most abundant around a shallow body of water in the midst of a piece of dense woodland, and they diminished in numbers the farther away one went from the pool, thus it seems probable that they bred in that body of water, even though at the time neither larvæ nor pupal skins could be found upon close examination. About thirty adults were taken alive and confined in breeding cages. They took blood readily, but one after another died off, until on September 8th there was but a single example left. Many of the dead ones had fully developed ovaries. On September 10th an egg-boat was found floating upon the water, laid by the last surviving female. The eggs hatched on the night of September 12th, and the young larvæ were transferred to strained water in which *Culex pipiens* had been breeding and into which pieces of stone, sod and decayed wood were placed in the hope that the larvæ would find in such a mixture some condition under which they might exist. Watched for several hours the larvæ rarely came to the surface, and only occasionally one or two were seen resting at the surface film. None lived more than six days, having apparently eaten nothing. The question still remains, therefore, as to just what the food of this larva is and under what conditions it lives. It has been suggested that they might be parasites, and this seems probable.

The egg-boat (Figure 8, 1) is quite similar to that of *Culex pipiens*, but is slightly larger, measuring 4.5 mm. at its greatest length and 2 mm. at its greatest width. It consisted of approximately 125 eggs, the individual egg being uniformly slaty-black in color, .75 mm. in height, broadest near the base and tapering regularly to a rounded apex. On account of the single eggs being longitudinally fastened together side by side and tapering apically, the top of the boat is very much smaller than bottom; indeed, some of the outside eggs are in an almost horizontal position.

The young larva (Figure 8, 2) is almost white in color and measures 1.5 mm., or .06 of an inch, in length from the head to the end of the ninth abdominal segment. The head is of the same color as the body, somewhat broader than long, well rounded in front, and

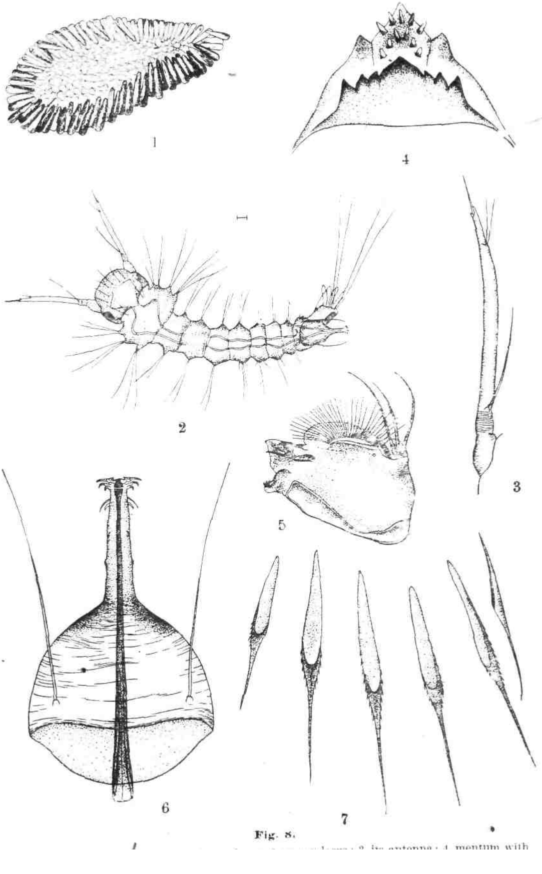


Fig. 8.

[illegible] its antenna; 4, mentum with

with distinct offsets immediately before the eyes, upon which rest the antennæ. Six single hairs on the anterior half of the head arise from minute pits; two of these are situated further in front than the others and occupy the central portion. The eyes are black and rounded. The antennæ (Figure 8, 3) are exceedingly long and slender, swollen at the base, followed by a wrinkled portion, immediately above which arises a single long seta from a distinct tubercle; a short distance from the apex is a slight offset which sends forth two moderately long hairs, and the apex of the shaft is terminated by a small peg and long, sharp spine. The mentum (Figure 8, 4) is broadly pentagonal in form, with one large central tooth and three smaller ones on each side, becoming successively larger toward the base; the attached hypopharynx is three-lobed; the central lobe set with short, stout pegs. The mandible is very singular, departing in some respects from that of all known species, and is best described by a reference to Figure 8, 5. It is a chunky affair, possessing the usual fan-like structure and three long and a short, stout spine on the dorsal aspect. The peculiar structure lies in the fleshy portion, which extends beyond the apex of the teeth, thus indicating some special mode of feeding. The thorax is broader than long, with deeply-cleft sides, forming large teeth-like projections, from the apices of which arise two to four long hairs; two pairs of shorter hairs are also on the anterior margin, which extend forward over the head. The abdominal segments, 1 to 7, are subquadrate in form, the anterior ones produced into sharp points at the sides, from the tips of each of which arise two long hairs; the posterior segments are more transverse, with one or two shorter hairs at the sides and with several additional short hairs. Upon the dorsum of the eighth segment is situated the anal siphon or air-tube (Figure 8, 6); this is broad at the basal half, then suddenly constricted, and continues narrowly to apex, there terminated by several recurved hooks. There is no double row of spines or pecten, but on the ventral side are two very long setæ from tubercles situated widely separate from each other. The eighth segment also bears the lateral row of scales (Figure 8, 7), five to eight in number, with long spine-like apices, arranged in a single regular row. The ninth segment is longer than broad, with a chitinized saddle on the dorsum extending one-fourth the width of the segment down the sides. Four very long double hairs constitute the usual double dorsal tufts, and a ventral brush is absent.

The anal gills are about the length of the anal segment and finger-like in shape.

Culex taeniorhynchus appeared in collections made at Elizabeth June 3d and at Staten Island June 4th. A beautiful female specimen was also captured in the act of biting at Lakehurst on August 17th.

Culex sylvicola proved rare, even in its native home at Livingston Park, during the past season. About fifteen full-grown larvæ were taken on April 25th and several pupæ on May 11th, all of which produced adults on or before the 15th of the latter month. A single adult, much battered and parasitized, was captured at Mount Holly June 8th.

Culex fitchii (Felt & Young) was found for the first time in New Jersey during the past year. Only two larvæ were secured and neither brought to maturity. One specimen occurred among a lot of *C. canadensis* sent in from Lahaway by Mr. Brakeley, and collected April 22d; the other found with *C. cantans* and *canadensis*, collected April 21st in the Great Piece meadows. Being thus taken in places so widely remote from each other, it is quite probable that the species occurs sparingly throughout the State. This brings the list of species actually found in New Jersey up to forty-two. The adult insect is said to be indistinguishable from that of *Culex abfitchii*, but the larva is separable at once by the position of the individual spines of the pecten on the air-tube; in *abfitchii* these are placed at equal distances apart from each other, or at most those nearer the apex are slightly wider apart than those nearest the base, while in *fitchii* the two apical spines are widely separated from the rest and from each other. This character is very constant, and is always to be relied upon. In other respects the two larvæ are alike.

Culex sylvestris appears to occur in New Jersey in two distinct forms, which may represent distinct species, though no good characters can be found that will positively separate the two forms at all times. One of these invariably hatches from early spring collections occurring with *C. canadensis, cantans* and other species in woodland pools. It is much the smaller of the two forms, is darker in general appearance, and occurs in comparatively very small numbers—two to ten specimens hatching from one lot as against hundreds of specimens of the other species. It is found from the middle of April until the same time in May. The second form is

much larger and has never been taken earlier than the first days of May, and more usually much later. It does not occur in woodland pools, except rarely in such as may be close to the open fields, but is usually found in open swamp areas, lot-pools with clayey bottoms, etc., where the larvæ are found sometimes in immense numbers, crowded together and associated with no other species. This latter form is common until the end of the season. It seems probable that we have here a dimorphic species to deal with, the scant early brood being parent to the succeeding generations. Certain it is that the large form has been found in May in pools that were not in existence the year previous, indicating conclusively that the eggs had been laid the same year.

Culex signifer, it has been intimated, hibernates in the larval condition. This we were at first inclined to doubt, since all of our previous collections of larvæ of this species had been made in September and all came to maturity before the end of that month. To test the point more thoroughly, however, Mr. H. O. Marsh, of Chester, collected all the larval contents of a tree-hole April 22d, in which *signifer* larvæ were found the preceding year. Larvæ of *Culex triseriatus*, one-third grown, were found in some numbers, but no *signifer* larvæ were among them. In September Mr. Dickerson found in the same tree-hole small and half-grown larvæ of *signifer*, and up to the time of writing (November 10th) many of these are still in the laboratory and none have reached the pupal stage. In confinement in glass jars, however, even though kept in water taken from the tree-hole, larvæ do not obtain the proper nourishment necessary to their development, and unless they are almost full grown, will merely continue to exist, scarcely growing larger, and may linger on for months, as has been demonstrated with various other species. In view of this fact Mr. Marsh was again requested to examine the "*signifer* hole," and on November 17th he secured a full brood of the larvæ in all stages, from small to almost full grown. With them were two large larvæ of *Culex triseriatus*. Mr. Marsh said that there was about nine inches of water in the hole, and that the surface was covered by three-fourths of an inch thickness of ice; nevertheless, he said the larvæ were moving about actively. It appears, therefore, that this species does hibernate as a larva, and that the adults emerge early in the spring of the following year. It seems not to breed continuously through-

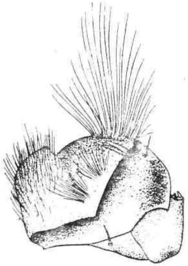
out the summer, appearing only in the fall after the maturation ‹ the hibernating brood.

Culex canadensis, whose larvæ in early spring usually crowd t woodland pools, was conspicuous by its almost entire absence duri the past year. It was present in some numbers in a few plac but as compared with former years this was entirely insignifica In the hilly districts of Millburn, where there are a great ma large woodland pools or "kettle-holes" most all of which form id breeding situations for this species, only a comparatively f larvæ occurred, and the resulting adults from this brood quick disappeared. Each year that we study this form produces ad tional evidence which points more and more to the fact that t species cannot be counted among the truly pestif ous ones. seems to disappear entirely a few weeks after emerging from t pupa, and this, coupled with the fact that it is rarely if ever fou out of the immediate woodland where it breeds, renders it o which needs but little consideration from an economic standpoi In the pools where they occur, however, certain other forms oc sionally develop which are a menace to close-by dwellings, and po treated for these will incidentally be freed from such *canadensis* may be present.

Culex triseriatus, which normally breeds in the vater in tr holes and has on only two occasions been reported as occurring el where, once in an iron kettle and once in a few pools formed by drying brook, was found breeding continuously in pails in my ba yard from mid-July until the end of August. The larvæ develop quickly, three distinct broods coming to maturity in that space time. Most of the larvæ were taken from the pails as they near maturity, but a few developed to adults outdoors, and one of the at one time was caught in the house toward evening. Two lar larval examples were taken with a full brood of *Culex signifer* Chester on November 17th.

Culex serratus was taken but once during the season, and th only half a dozen larvæ occurred among a lot of *C. sylvestr* secured by Mr. Brehme, August 6th, on the Orange mountains, new locality for its occurrence.

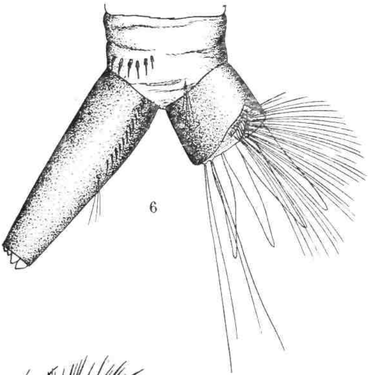
Culex punctor, taken in New Jersey in 1905 for the first tim and then only as an adult, was found in 1906 as a larva on t Orange mountains and in the Livingston Park woodland area ne



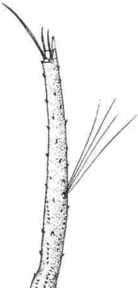
4

7

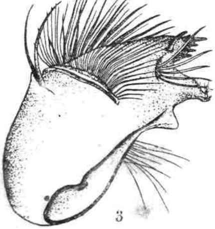
5



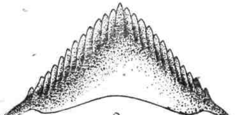
6



1



3



2

New Brunswick. It appears to be among the earliest of our spring species. In 1905 adults hatched May 1st from pupæ collected April 28th, but no larvæ could be found among those still remaining unchanged, all having already transformed to the following stage. In 1906 the first larva was taken April 20th, associated with *C. canadensis* in a woodland pool on the Orange mountains. This changed to a pupa on the 23d and produced a male adult on April 27th. Two other larvæ were taken from the same locality on the 24th of April. On the 25th quite a number were secured from Livingston Park also in company with *canadensis*, and from this lot eleven males and three females emerged in the six days following. The larva has hitherto not been well described by this office, the description appearing in the preceding report being obtained from published data. It may be characterized as follows:

When full grown it is about 7 mm. or .28 of an inch in length, exclusive of the anal siphon. It is more robust than *canadensis*, though scarcely larger, and can usually be distinguished from that species by this fact alone. In color it is dirty yellowish-gray. The head is considerably broader than long, slightly excavated below the antennal offset and well rounded in front; four single hairs are on the central portion of the vertex, the posterior two situated immediately in front of the median line, the anterior two slightly in advance of these, and both lateral pairs placed rather wide apart. A single tuft of three hairs is at the base of each antenna. The antenna (Figure 9, 1) is uniformly grayish-brown in color, of moderate size, slightly and regularly curved inward, somewhat excavated a short distance from the base, giving the extreme base a swollen appearance, and terminated by one very long spine, three shorter ones and a short, stubby peg. The tuft, composed of four to six hairs, is situated on the shaft a little below the middle, and the surface of the antenna is set with short, stout spines and several rows of minute ones on the basal half. The mentum (Figure 9, 2) is broadly triangular with twelve or thirteen small regular teeth on each side of the apex. The mandible and palpus (Figure 9, 3 and 4), respectively, are of the usual *Culex* type and are best described by referring to the figures. The thorax is rather large and robust, with slight lateral angles which give rise to tufts of long hair; two smaller tufts are on the anterior margin. The abdominal segments from one to seven are subquadrate as usual.

with lateral hair tufts. The eighth segment bears the latera scales; these are composed or six or seven single scales arrange in a regular curved row. The individual scale (Figure 9, 5) ha a very long and strong apical spine and a number of small, hai like ones fringe the sides, the one near the apical spine being muc the largest. The anal siphon (Figure 9, 6) is a little over thre times as long as broad and tapers evenly toward the apex. Th double pecten is composed of twelve to fifteen spines, the singl spine with two to five teeth on the basal portion, usually the fewe the number the larger their size as shown in Figure 9, 7. Th anal segment is a little broader than long and entirely encircled b the chitinous ring. The double dorsal tuft and dorsal brush ar normal and the anal gills are longer than the ninth segment an somewhat pointed.

Culex triviittatus was obtained in some numbers by Mr. Brehm in the Orange mountains June 5th, in a pool with a large broo of *Culex sylvestris.* Though almost full grown they proved har to rear and only six adults, three of each sex, were secured. few other larvæ were taken at Millburn, also with *sylvestris*, o June 4th.

Culex pretans occurred again as larvæ in great numbers i early spring in the Great Piece meadows, replacing *C. canc densis* in that place. Though absolutely no additional larvæ wer taken subsequent to April 30th, adults were found on the wing a late as September 13th. Specimens taken at that time were cage and fed on banana and human blood, but all died in a few day without ovipositing. Examination of the specimens showed n eggs within the body and it is more than likely that the eggs ha already been laid.

Culex aurifer, usually taken by Mr. Brakeley, proved rather rare Only two larvæ were sent in by him, April 22d, and another wa collected in the Great Piece meadows on April 21st. Adults wer found in annoying numbers July 5th, in a patch of woodland o the east side of Lake Hopatcong.

Culex restuans was more abundant than in 1904 and 1905. I occurred quite generally in my breeding pails, appearing a littl after the beginning of July, and was obtained from roadside pud dles as late as the 16th of October. To it, in conjunction witl

Culex pipiens, may be charged some of the sleepless nights that were experienced last season.

Culex salinarius also occurred quite generally over the salt marsh—never, however, appearing in very large numbers. They appeared about midsummer and were found as late as the early part of November. On August 13th, a single female was caught on the South Amboy meadow. It was caged and given a meal of blood, which it readily took, and on the 18th laid a loosely-constructed egg-boat, aggregating, approximately, seventy-five eggs. The young larvæ hatched on the 20th, ten making their advent at 3 o'clock P. M. and five others at 5 P. M., showing that the larvæ do not hatch simultaneously. They grew rapidly, considering their confinement, and on August 30th the first pupa was formed. This hatched September 1st and by September 7th the last of the entire lot had emerged.

This species occurs as late into the season as any other New Jersey form. Mr. Brehme reported an interesting observation, in November, 1905, which came too late for incorporation into the report for that year. He found full-grown larvæ in a pool on the Elizabeth marshes, which was covered with ice to the thickness of almost one-fourth of an inch that had formed during the preceding night. After the ice had been broken he found the larvæ lying at the bottom of the pool, and when scooped up with a net and transferred to a bottle showed scarcely any signs of life. In about five minutes (the bottle being exposed to the sun's rays) they began to wriggle slowly to the surface. When it was reached they ceased to wriggle and immediately sank to the bottom again. They then remained at the bottom for fully five minutes, and probably longer, before another attempt was made to obtain a fresh supply of air. It was not very long, however, before they were as active as ever, and in the laboratory almost all of them came to maturity.

Culex territans was found in my pails kept for breeding purposes on August 4th. This species confines itself, usually, to clear, fresh-water pools, and it is rare to find them in a water pail.

Uranotaenia sapphirina, a rather rare species in New Jersey, was taken in various stages of development in a woodland water area of the Great Piece meadows. The larvæ were very hard to rear, and, though a few reached the pupal stage, none became adult.

Of the species of Corethridæ, *Corethra cinctipes* was of rather

common occurrence in early spring collections from woodland pools. *Sayomyia albipes* was unusually rare, being taken only once at Millburn, on May 28th, while *Corethrella brakeleyi* was sent in by Mr. Brakeley in some numbers from Lahaway on April 20th. Full-grown larvæ of *S. albipes* were taken in the fall of 1905 and lived in the laboratory until January, 1906. They would probably have lived all winter were it not that no vegetation was growing in the jar in which they were confined, and the oxygen thus becoming exhausted resulted in their death. The larvæ of *C. brakeleyi*, on account of the grasping form of the antennæ and the sharp-toothed structure of the mandibles, were believed to be predaceous in habit, and during the present year one larva was seen with another half-devoured individual of the same species in its jaws. The larva of an allied species described during the past year was observed feeding upon a minute crustaceans.

3545
17 JUN 1936